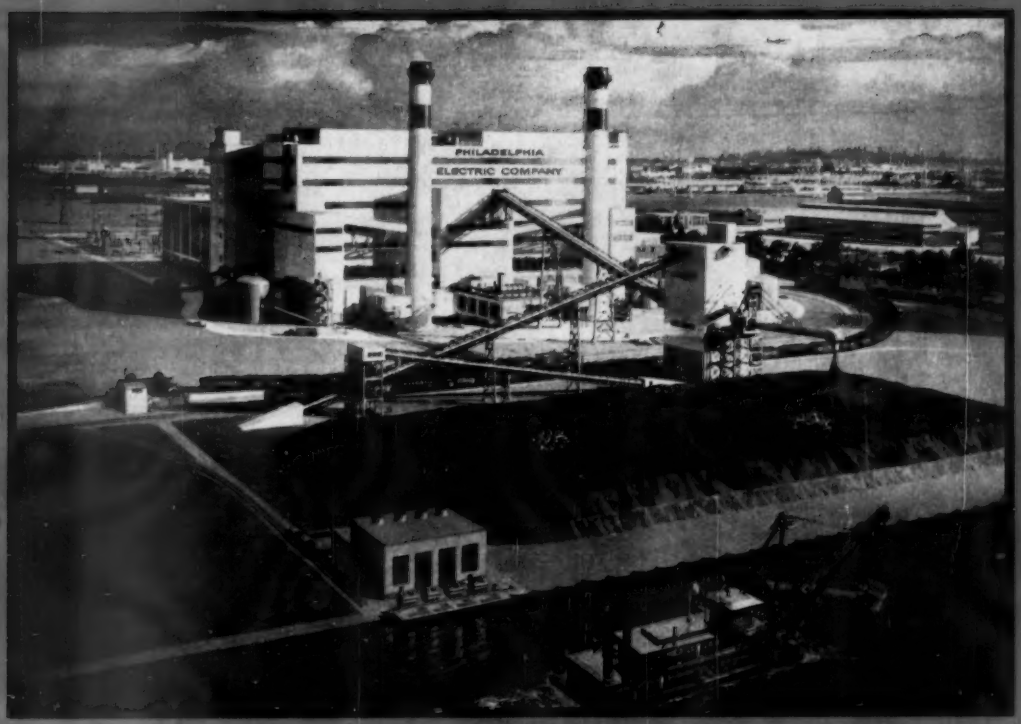
COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

September 1959



Artist's impression of the Eddystone Station of Philadelphia Electric Co. whose initial unit will be a 325,000-kw, super-critical pressure, 5000-psi, 1200-F double reheat steam generator.

High Temperature Hot Water at Air Force Academy

Power Plant Clinic

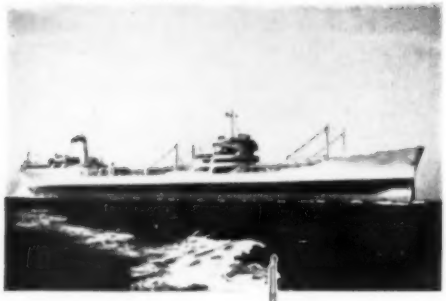
Cooling Tower Fans

Automatically Fired Boilers

In the service of pleasure...commerce...national defense

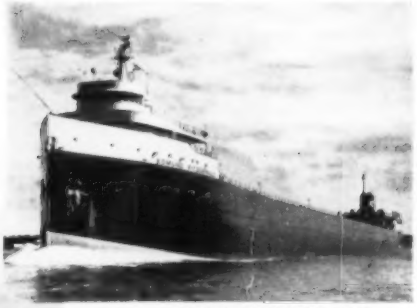
C-E BOILERS POWER ALL TYPES OF SHIPS

USNS YUKON

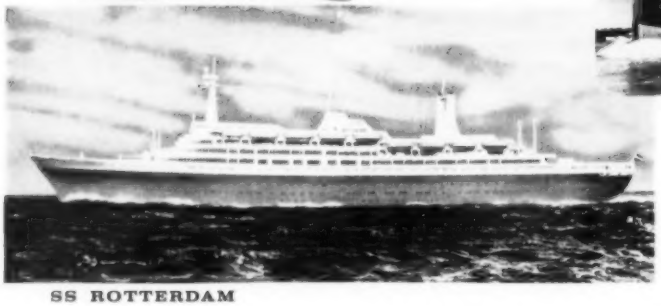


USS RIGEL

C-222A



SS FITZGERALD



SS ROTTERDAM

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ALL TYPES OF STEAM GENERATING, FUEL BURNING AND RELATED EQUIPMENT; NUCLEAR REACTORS; PAPER MILL EQUIPMENT; PULVERIZERS; FLASH DRYING SYSTEMS; PRESSURE VESSELS; SOIL PIPE

COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

Vol. 31 **No. 3**

September 1959

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BPA

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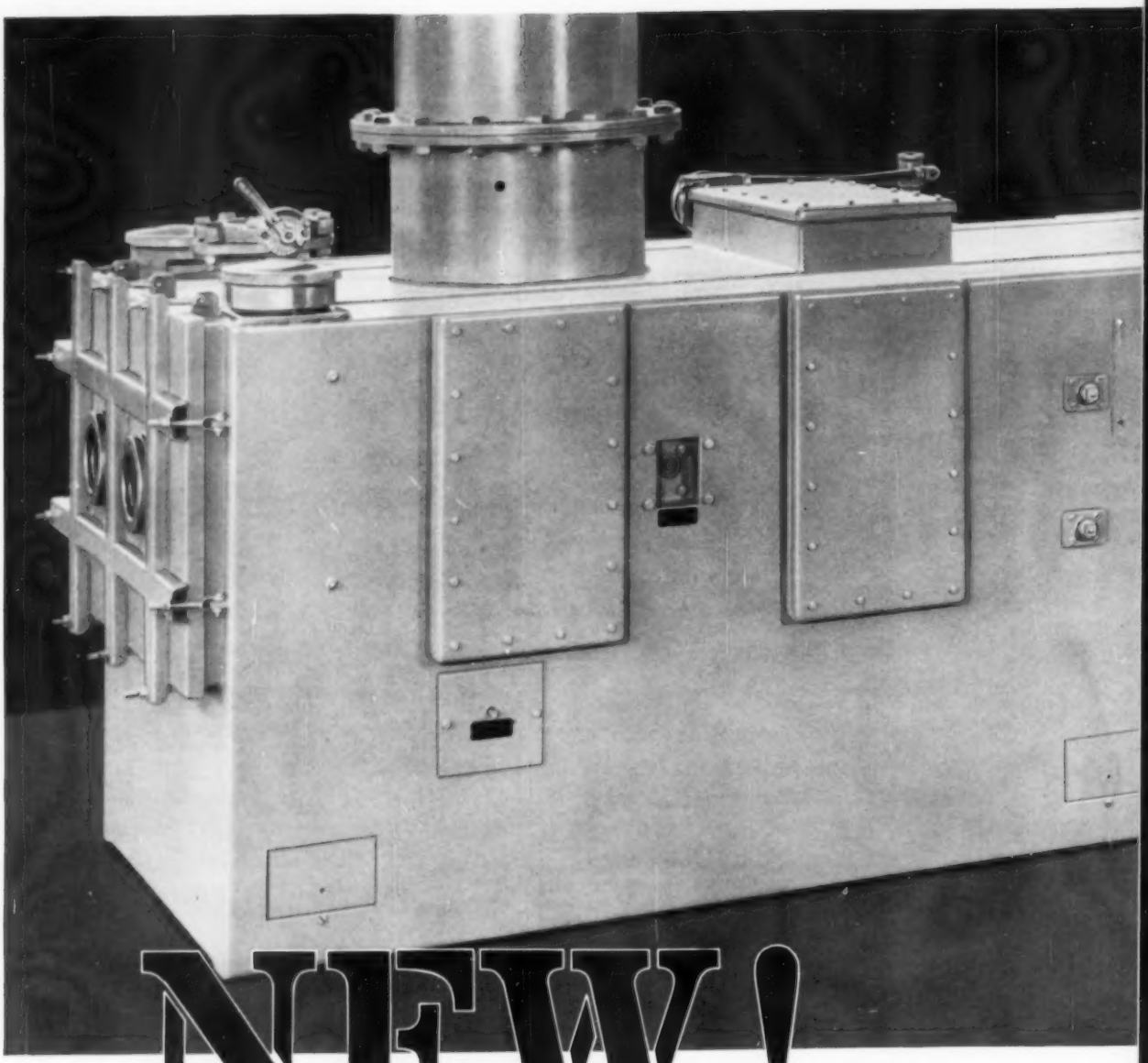
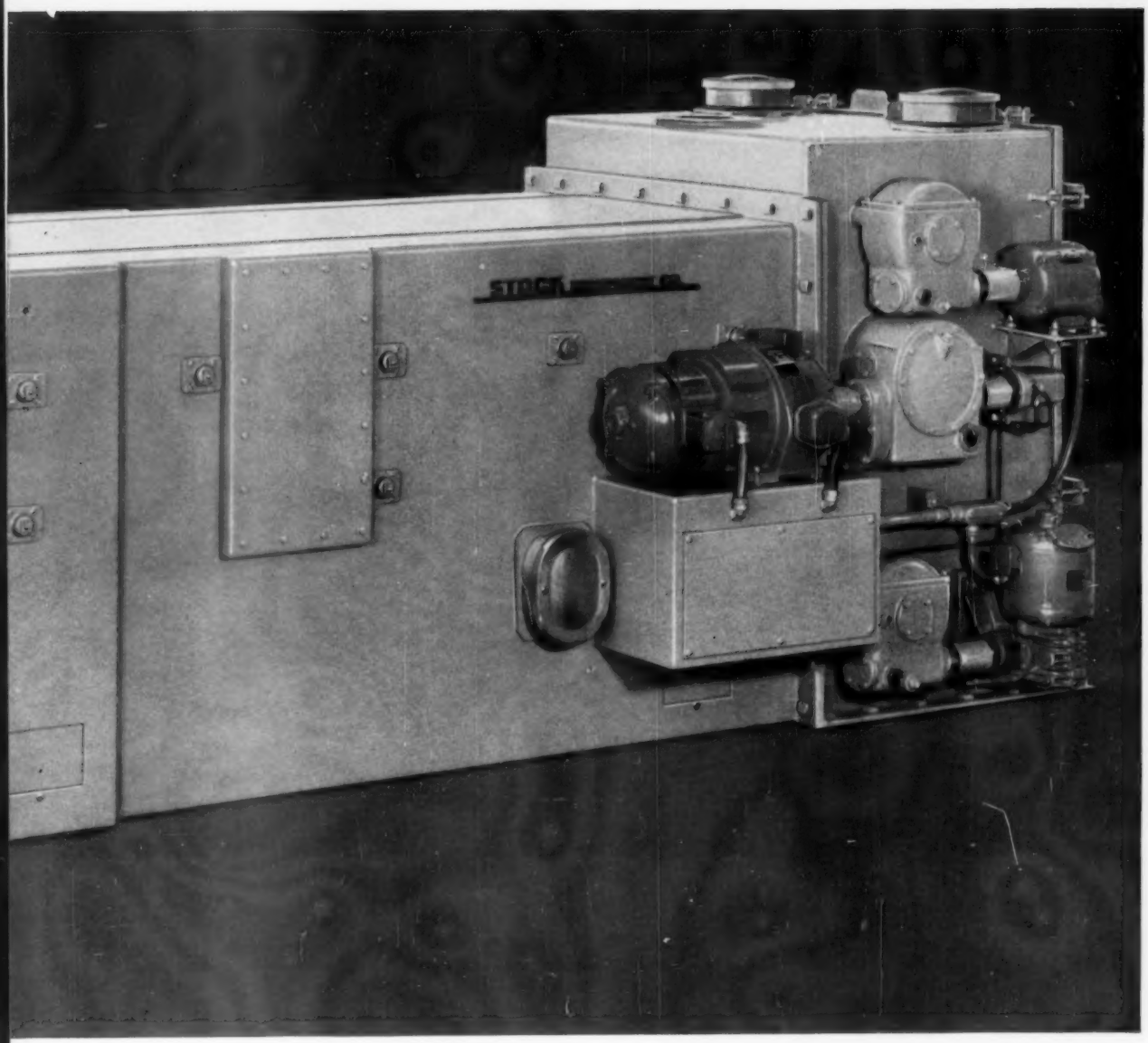


NEW!

A COMPLETE LINE OF

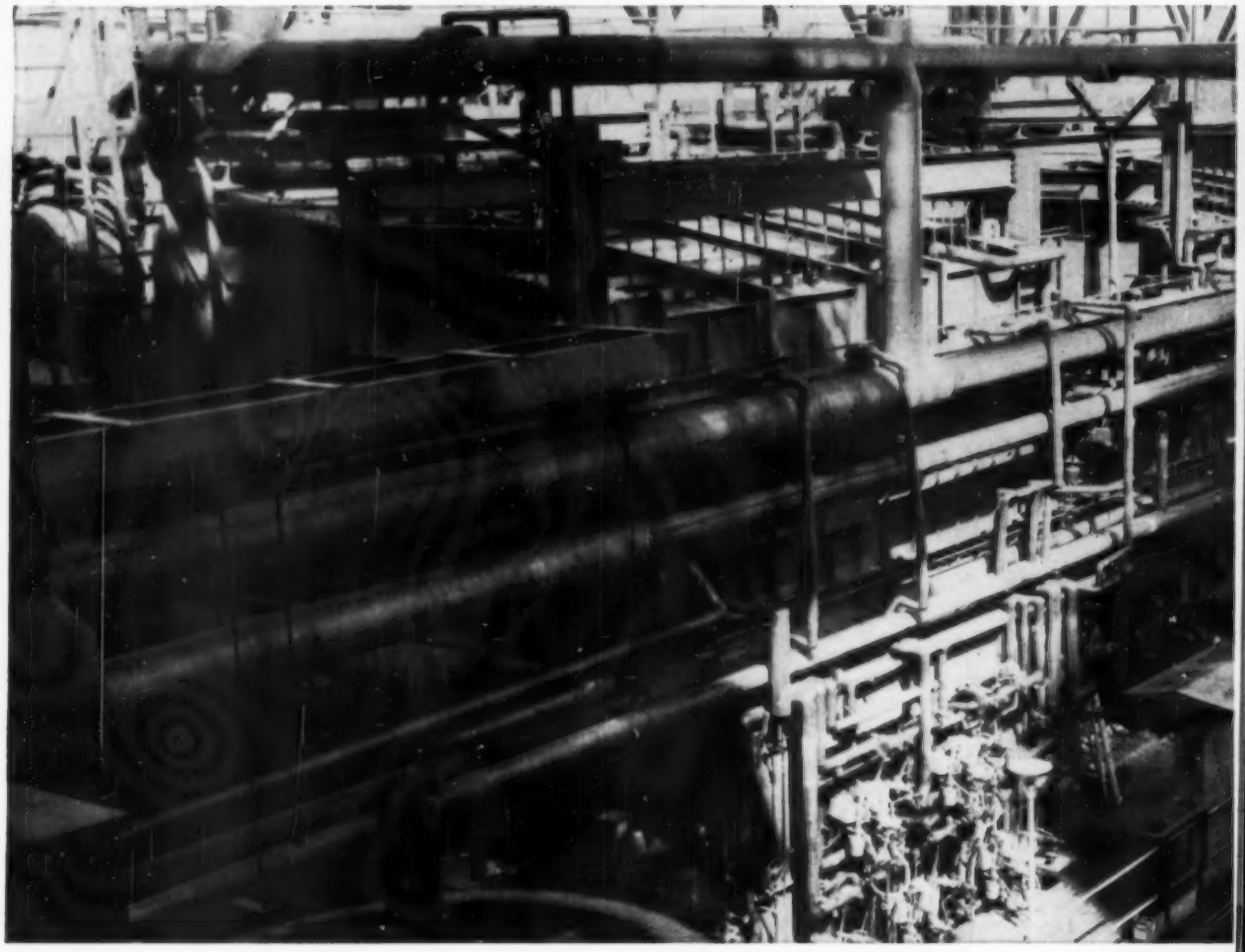
VOLUMETRIC BELT FEEDERS



To assure more reliable coal flow to pulverizers and cyclone burners, Stock Equipment Company has developed a complete line of Volumetric Feeders. The unrestricted 24" width of coal stream is only one feature contributing to completely satisfactory operation even with fine, wet, sticky coal and with coal containing frozen or oversized pieces. The endless rubber belt used in the S-E-Co. Volumetric Feeder together with perfection in mechanical details provides long life with low maintenance.

Include S-E-Co. Volumetric Feeders in your next boiler specification.
Write for Bulletin!

by STOCK Equipment Company
749 HANNA BUILDING • CLEVELAND 15, OHIO



Copes-Vulcan boiler control load conditions at Deepwater

In addition to producing power for the Atlantic City Electric Company system, the Deepwater plant delivers steam to an adjacent chemical plant for process use.

To meet the widely fluctuating process demands, Copes-Vulcan controls the two low pressure boilers with precision responsiveness. Each boiler has a maximum continuous rating of 150,000 pounds per hour at 230 psig saturated. The system consists of:

Combustion Control maintaining a constant pressure in the main process steam header by holding steam output from the boiler equal to steam demand.

Copes-Type 3-L Feedwater Control modulated by three control influences—steam flow, feedwater flow and drum water level.

Boiler feed pump recirculation control protecting the boiler feed pumps against overheating on light loads.

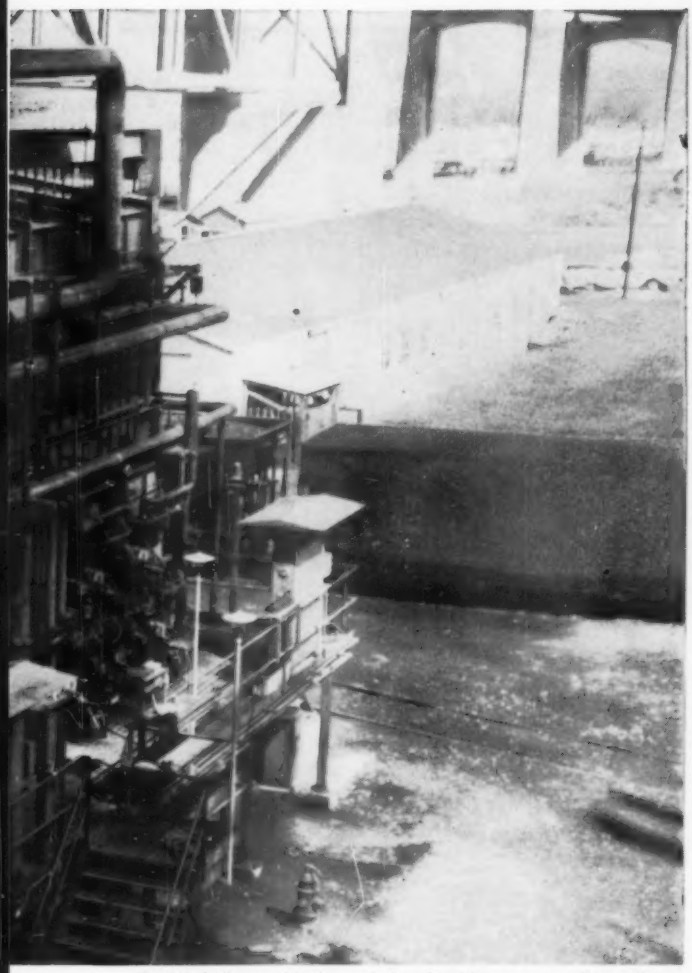
Vulcan Rotary Soot Blowers providing positive cleaning over the full blower arc, which may be as much as 360 degrees.

The system controls all equipment with either one or two boilers in service, permits each boiler to carry a different load. Control is automatic through a load range of 20,000 to 200,000 pounds per hour.

Whether your boiler is large or small, power or process, Copes-Vulcan can provide a unit or an integrated package, custom designed to your requirements. **For details on the Deepwater Station installation, write for Bulletin 1057.**

Copes-Vulcan Division
BLAW-KNOX COMPANY • Erie 4, Pennsylvania

BLAW-KNOX



Outside boilers and boiler controls subject to severe weather, with temperatures as low as 10° F. Except for the central control panel and relays and controllers mounted on it, the Copes-Vulcan control system is entirely outdoors.

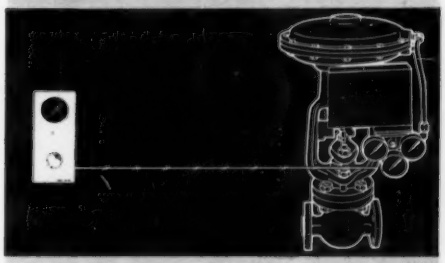
meets unusual Station

Diaphragm-operated CV-D valve controls the speed of the turbine driving the forced-draft fan. Copes-Vulcan also makes piston-actuated valves. Both types meet pressure standards of 125 to 2500 pounds.

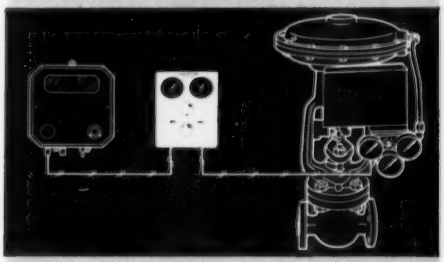
The drive unit with positioner, 4-way valve, power piston and feedback cam controls forced-draft damper. C-V drive units permit remote positioning by automatic or manual pneumatic signals.

C-V NEWS NOTES

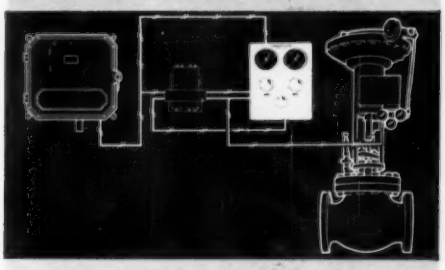
PNEUMATIC CONTROL STATIONS



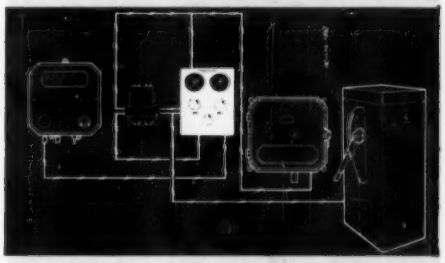
Copes-Vulcan stations offer automatic-to-manual selection without the complication of seal balance. They indicate process-variable, controller and manual loadings. Transfer is "bumpless" without process disturbance. Shown above: the ML-4 Manual Loading Station.



AM-4 Selector Station . . . indicates an automatic loading—or originates a manual loading—to the valve, power cylinder or other control element.



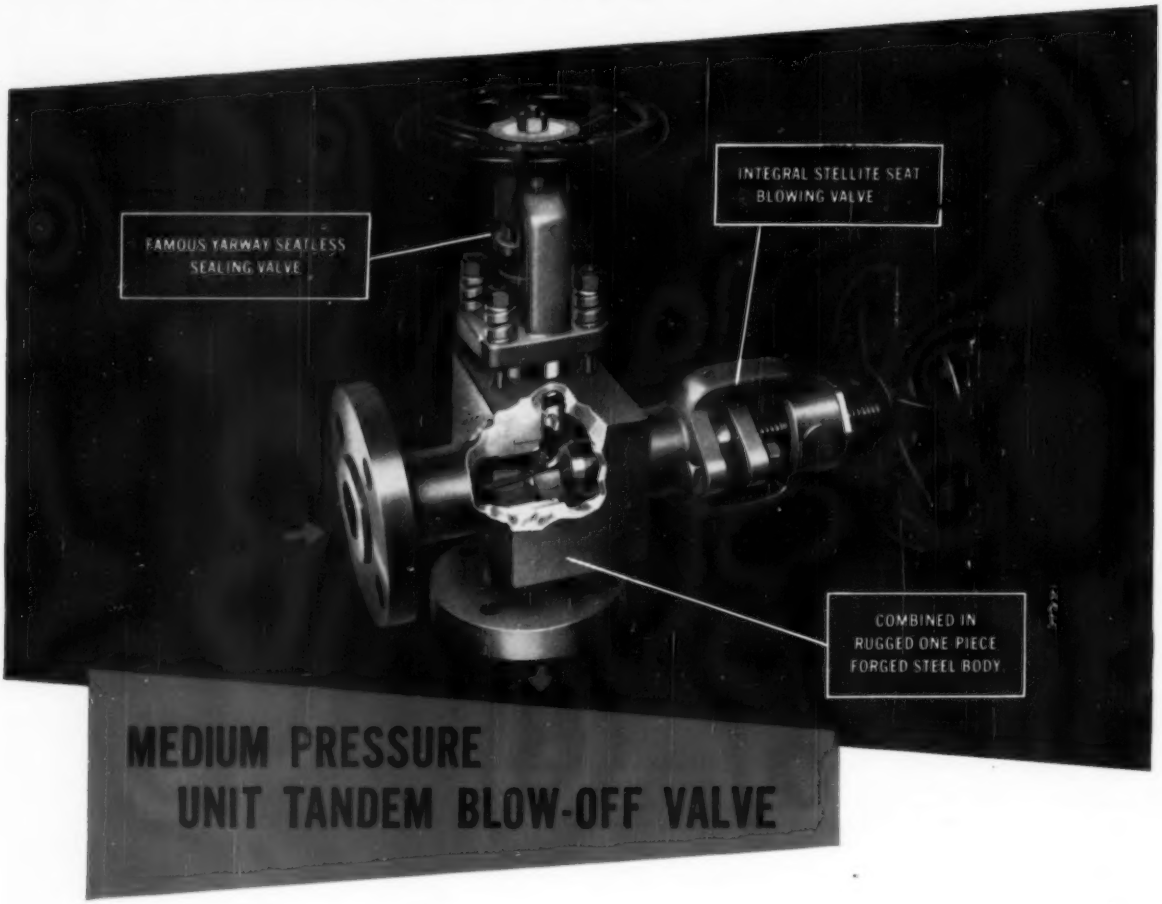
AMS-4 Remote Set Station permits manually adjustable set-point loading, or independent manual operation, of the control element.



AMBC-4 Cascade Biasing Station, used with pneumatic stacked diaphragm controllers, permits plus-or-minus biasing of a cascaded set-point to the controller.

For details about Copes-Vulcan's complete line of pneumatic control stations, write for Bulletin 1031.

NEW YARWAY MEDIUM PRESSURE BLOW-OFF VALVE FEATURES HIGH PRESSURE DEPENDABILITY


FAMOUS YARWAY SEATLESS SEALING VALVE
INTEGRAL STELLITE SEAT BLOWING VALVE
COMBINED IN RUGGED ONE PIECE FORGED STEEL BODY
MEDIUM PRESSURE UNIT TANDEM BLOW-OFF VALVE

The established success of the high pressure Yarway Unit Tandem Valve is directly responsible for this new medium pressure Yarway Valve. It brings premium quality Yarway dependability to medium pressure boilers (up to 665 psi)—*at a competitive price.*

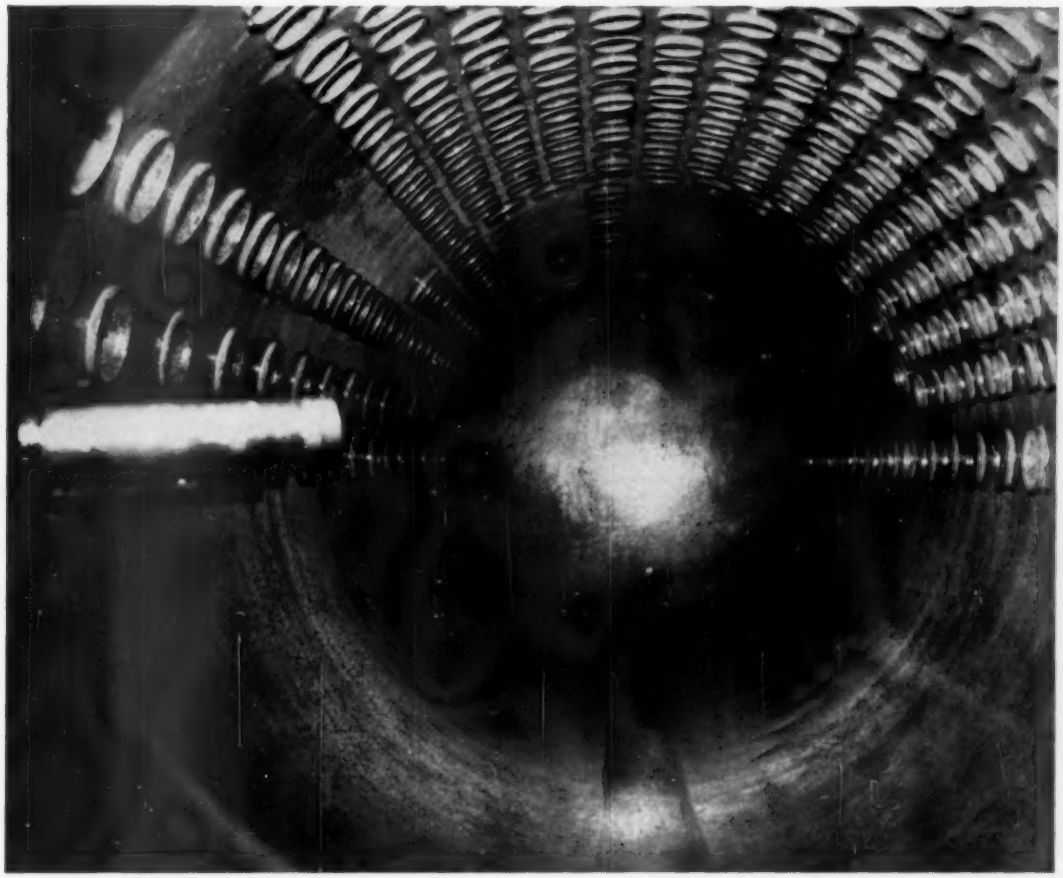
Important Yarway features like nitralloy plunger in the sealing valve, integral stellite seat and disc in the blowing valve, streamlined design, rugged forged steel body—make this your best blow-off valve buy.

Install this new Yarway Medium Pressure Unit Tandem and you'll know why *over 80% of all high pressure plants are Yarway Blow-off Valves.*

Write for Bulletin B-435, Supplement A.

YARNALL-WARING COMPANY
100 Mermaid Ave., Philadelphia 18, Pa.
BRANCH OFFICES IN PRINCIPAL CITIES

YARWAY
A MARK OF QUALITY IN STEAM ENGINEERING



No Sludge . . . No Scale . . . No Corrosion in this boiler

Opened for inspection, this large boiler drum shows the results of a year's attention to good water treatment: *nothing!* No sludge, no scale, no corrosion . . . Ready to go back on line without even a wash-out . . . Down time and maintenance minimum, fuel economy and operating efficiency tops . . . Thanks to The Nalco System of Water Treatment, and good plant control practices.

Nalco System treatment includes proper water treating chemicals *plus continuing Nalco service* that assures effective protection for your steam and water system—from raw water intake through condensate return lines.

For prompt action and straightforward assistance on any water treatment problem, call on Nalco.

National Aluminate Corporation is now

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LOOK TO NALCO FOR GOOD WATER TREATMENT

and for:

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- PAPER MILL PROCESS CHEMICALS
- ION EXCHANGE
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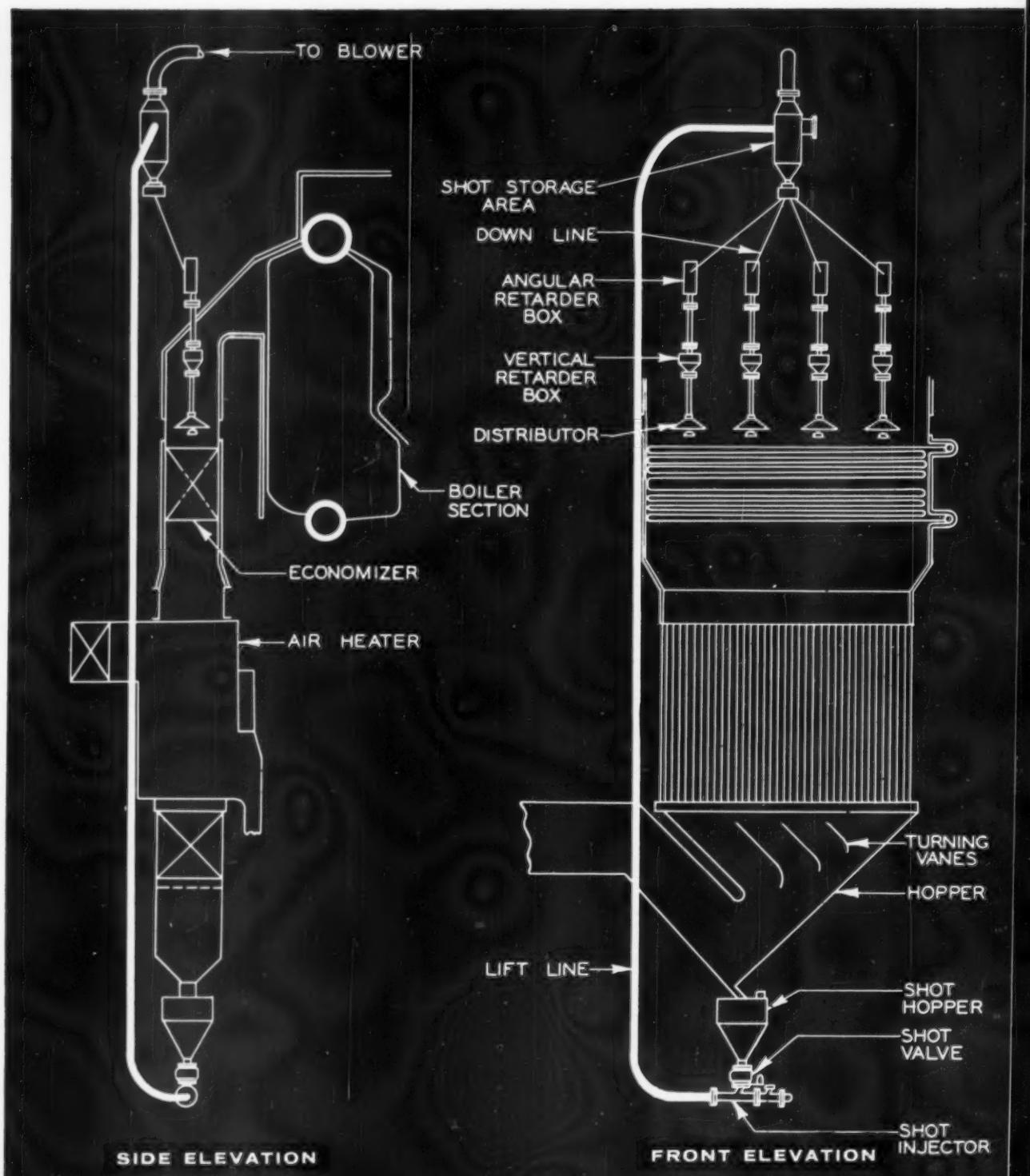
- COMBUSTION CATALYSTS
- PETROLEUM CATALYSTS
- FUEL OIL STABILIZATION
- OIL WELL AND REFINERY CORROSION CONTROL

THE *Nalco*® SYSTEM . . . SERVING INDUSTRY THROUGH PRACTICAL APPLIED SCIENCE

Nalco CHEMICALS Nalco SERVICES



TYPICAL SHOT CLEANING SYSTEM

DIAMOND
SHOT CLEANING

Its Advantages

This system offers much improved cleaning of certain areas of boilers such as tubular air heaters, horizontal superheaters, economizers, and reheaters. It will often accomplish effective cleaning where this has not been possible previously. Areas which tend to foul rapidly may be kept completely clean by increasing the length of the automatic shot cycle (it may be continuous if necessary) without disturbing boiler operation. No platforms or galleries are needed as with conventional cleaning equipment so aisle space often may be reduced.

Uniformly low draft loss and constant flue gas temperature are easily maintained because deposits are removed before they impair the thermal efficiency of the plant.

How It Works

Falling shot, spread uniformly by distributors scours the fouled area. Deposits are removed in small particles, most of which are carried away by the gas stream. Heavier particles fall into the shot hopper and recirculate with the shot until broken fine enough to pass out with the gases. Cleaning is thorough even with difficult fouling such as is found in black liquor fired boilers. The same quantity of shot will clean the entire vertical section with no limitations in height.

Operation is automatic. Shot is lifted pneumatically from the hopper to a shot storage area where it falls by gravity through retarder boxes to the distributors. Length and frequency of cleaning cycle are chosen according to the fouling rate of the area and the type of deposit.

Cleaning is accomplished by thousands of steel shot that cascade over tube surfaces and ricochet from tube to tube, or through the insides of air heater tubes.

More than 30 Diamond Shot Cleaning Systems are now in successful operation in the United States . . . some of them since 1954. This is the result of Diamond's extensive research in shot cleaning over a period of years. In Europe shot cleaning has been in use over ten years and there are more than 800 installations in highly satisfactory operation. To supplement our developments, Diamond has acquired U.S. rights to the Broman-Ekstrom System used in Europe.

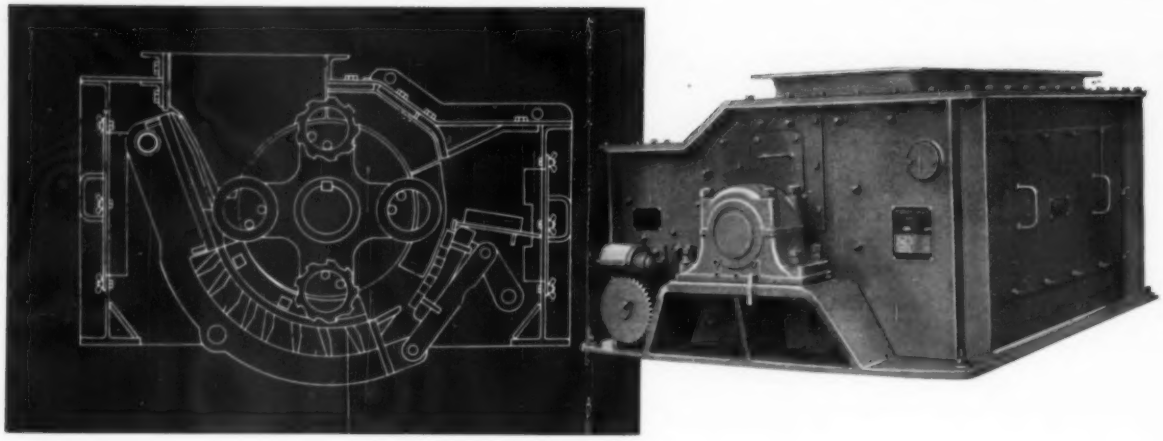
DIAMOND POWER SPECIALTY CORP.

LANCASTER, OHIO

WRITE FOR BULLETIN 2145.

It gives complete details on Diamond Shot Cleaning. For better, more economical boiler cleaning, the answer always is Diamond.

8255



TRAMP IRON FALLS INTO A TRAP

When preparing coal with the Pennsylvania Ring Granulator you've automatically eliminated any chance of tramp iron causing trouble. This is due to the tramp iron trap in the Granulator. Any outlaw material too large to pass through the cage bars is carried on across the cage bar area and dropped into the tramp iron pocket. A curved deflector plate prevents the unwanted material from continuing around the rotor and entering the crushing cycle again, or shooting out the hopper. This great crusher has a lot more features that have given it leadership wherever coal is crushed. Bulletin 9004 gives you complete details. Ask for it. Pennsylvania Crusher Division, Bath Iron Works Corporation, West Chester, Penna.

Pennsylvania CRUSHERS

PE-310

DAMPNEY COATINGS LIVE WITH IT!

True measure of a high-heat coating's worth is *continuous operation at rated temperature.* Yet many so-called "heat-resistant" coatings take only occasional peaks — fail rapidly in 'round-the-clock service.

Dampney coatings are rated always for day in, day out operation at maximum temperatures. Hold them to it, if schedules call for steady heat, or let them fluctuate to ambient and back. Either way, Dampney silicones and ceramics give you full protection — with plenty in reserve.

Most important, Dampney coatings are selected to meet specific conditions of operation, temperature and corrosive environment. Thus they establish a lasting foundation easily maintained and permanently ending time-consuming and costly surface preparation.

Repeat orders — from a typical customer, 26 in 12 months for enough material to protect 1,929,000 square feet of steel — is the best evidence we have that when industry wants honest high-temperature coatings, it remembers Dampney silicones and ceramics, identified by the two trade names, DAMPNEY and THUR-MA-LOX.

We suggest you do likewise when you want real protection — resistant to 1000°F., to atmospheric corrosion, and to weather exposure — for these industrial hot spots . . .

stacks and breechings	turbine interiors
steam lines	precipitators
kilns	coke ovens
forced and induced draft fans	incinerators
heat-treating furnaces	pulverizers
autoclaves and retorts	blast and open hearth furnaces

Remember, too, the first Dampney trade name and product, known and used today the world around, APEXIOR NUMBER 1 for boiler interiors. For all hot metal, wet or dry, the best protection available is made and marketed by

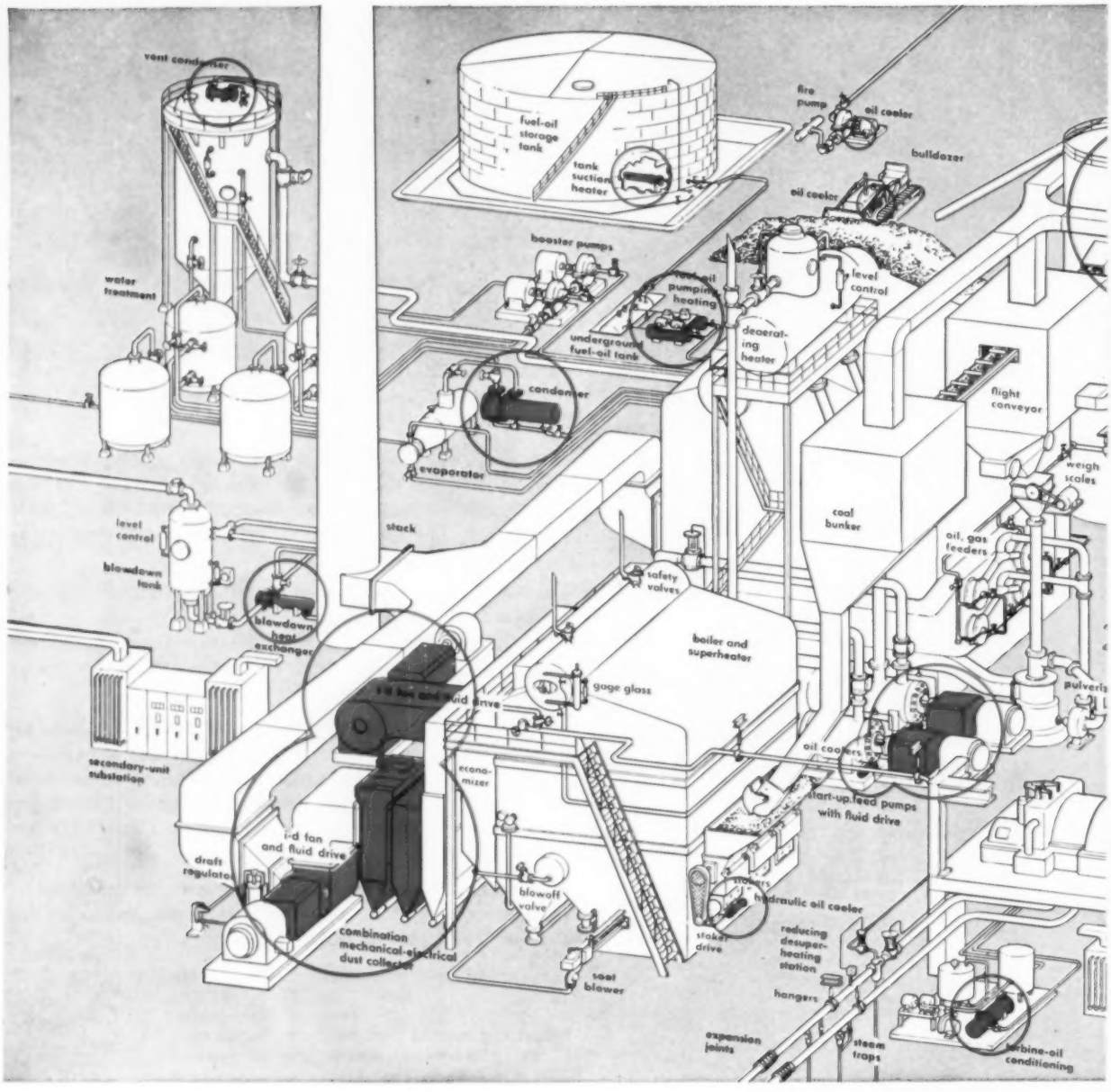
MAINTENANCE FOR METAL

THE DAMPNEY COMPANY

HYDE PARK, BOSTON 36, MASSACHUSETTS

Coatings for all temperatures to high heat— all corrosive environments.

207



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THIS LAYOUT of a modern steam power plant could be yours today or a blueprint of your future one. It could be a central-station or an industrial plant.

As you can see for yourself, American-Standard* Industrial Division products play a vital role — no matter what size plant you plan.

Standard or special, primary equipment or machine components, large or small, one of a kind or dozens alike — American-Standard Industrial Division products are designed and built for optimum performance in every type of service within the modern steam power plant.

An American-Standard Industrial Division product specialist in consultation with your engineer not only has much to offer in the way of equipment, but extensive experience as well. The combined product lines of American-Standard Industrial Division—American Blower, Ross Heat Exchanger, and Kewanee Boiler—are renowned in the power-generation field—utilities, industries, institutions, major buildings, engineering and contracting firms throughout the world.

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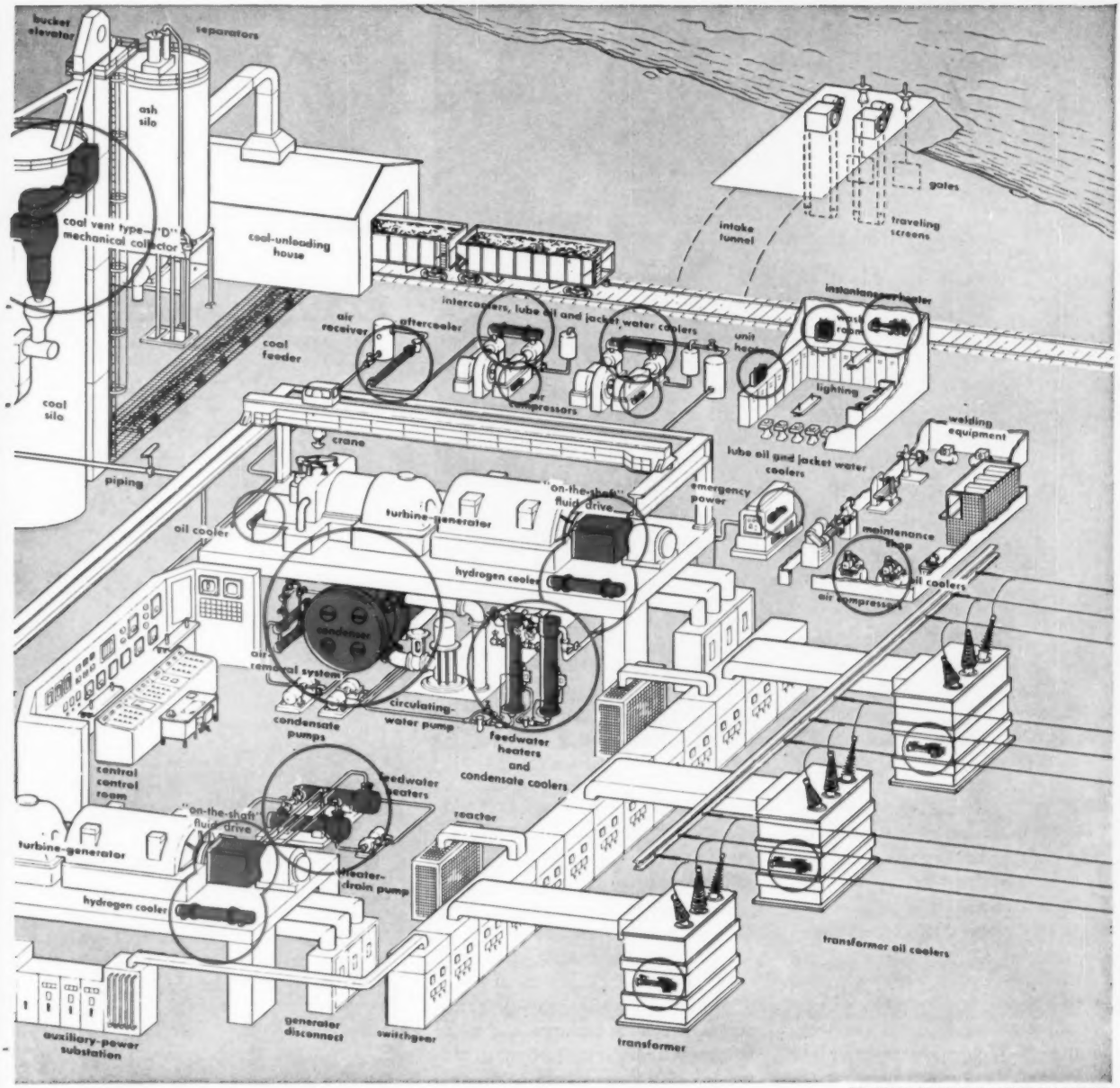

DRAWING COURTESY POWER MAGAZINE

perform numerous services in a modern steam plant

For information on specific products — or reprints of this advertisement — contact the American-Standard Industrial Division office nearest you.

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AMERICAN-Standard
INDUSTRIAL DIVISION

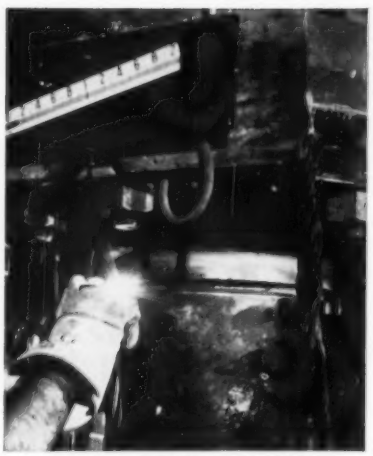
AMERICAN BLOWER PRODUCTS • ROSS PRODUCTS • KEWANEE PRODUCTS

KELLOGG'S K-WELDING IN THE FIELD KEEPS PACE

Once restricted to shop fabrication, K-Weld® has recently been successfully adapted by Kellogg to meet the severest specifications for welding high-pressure-temperature power piping in the field. Currently it is being used in the erection of supercritical piping systems for some of the country's leading steam-electric utilities.

Unique among field welding techniques, K-Weld assures complete penetration of the root bead and a highly uniform internal contour *without backing rings*—through the use of controlled inert gas pressure inside the pipe. The technique can be used on pipe of any type or size during shop fabrication or in the field.

Kellogg welcomes inquiries on K-Weld and its complete service to the power piping industry from consulting engineers, engineers of power generating companies, and manufacturers of boilers, turbines, and allied equipment. An introduction to this service may be obtained by writing for Kellogg's new 12-page booklet, "The Eddystone Story".



As welder lays K-Weld root bead, he carefully controls the pressure of the inert gas. Using this technique, the root bead can be made slightly convex, flush or concave, and the weld deposited with a highly uniform internal contour. No backing rings are needed.

Fabricated Products Sales Division

THE M. W. KELLOGG COMPANY, 711 THIRD AVENUE, NEW YORK 17, N. Y.

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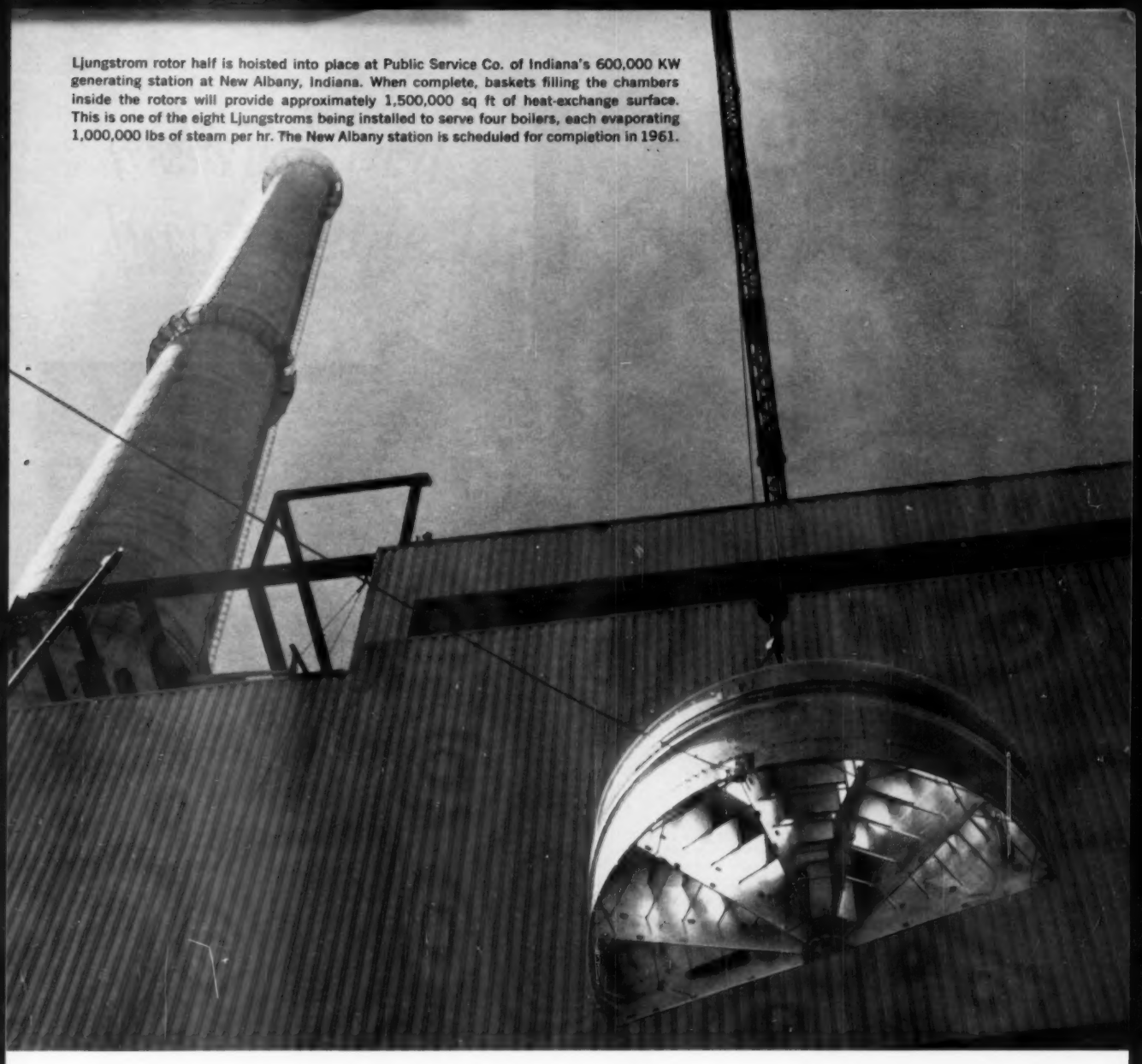
POWER PIPING—THE VITAL LINK

®Registered trademark of the M. W. Kellogg Company, Process Patented



Ljungstrom rotor half is hoisted into place at Public Service Co. of Indiana's 600,000 KW generating station at New Albany, Indiana. When complete, baskets filling the chambers inside the rotors will provide approximately 1,500,000 sq ft of heat-exchange surface. This is one of the eight Ljungstroms being installed to serve four boilers, each evaporating 1,000,000 lbs of steam per hr. The New Albany station is scheduled for completion in 1961.

BEHIND NEW ALBANY'S **LJUNGSTROMS®** —**LIFETIME AIR PREHEATER SERVICE**

One of the major reasons why Public Service Co. of Indiana, Inc., chose Ljungstrom for its new generating station at New Albany is Lifetime Air Preheater Service.

Lifetime Air Preheater Service means that Ljungstrom engineers make regular calls *throughout the life of each unit.* They check to make sure your Ljungstroms are working at top efficiency, and that they'll continue to work that way. This service policy covers all Ljungstroms—right from the very first installation made in 1923.

But that's not all. Air Preheater provides first-rate *emergency* service, too. For instance, a Ljungstrom customer in the southwestern U.S. recently called on a Wednesday night for replacement parts. Air Transport looked like the fastest way, but schedules indicated a minimum three-day delivery time. So Air Preheater loaded the parts on a pickup truck, and their men drove them more than 1,000 miles to their destination...34 hours straight driving. The parts were installed and in service by Friday morning.

Fast response to emergencies and regular inspection of Ljungstrom installations are two of the many advantages Air Preheater provides. Another is expert knowledge of boiler and preheater problems gained from over 35 years' experience. Perhaps these reasons explain why 9 out of 10 preheaters sold today are Ljungstroms.

THE AIR PREHEATER CORPORATION

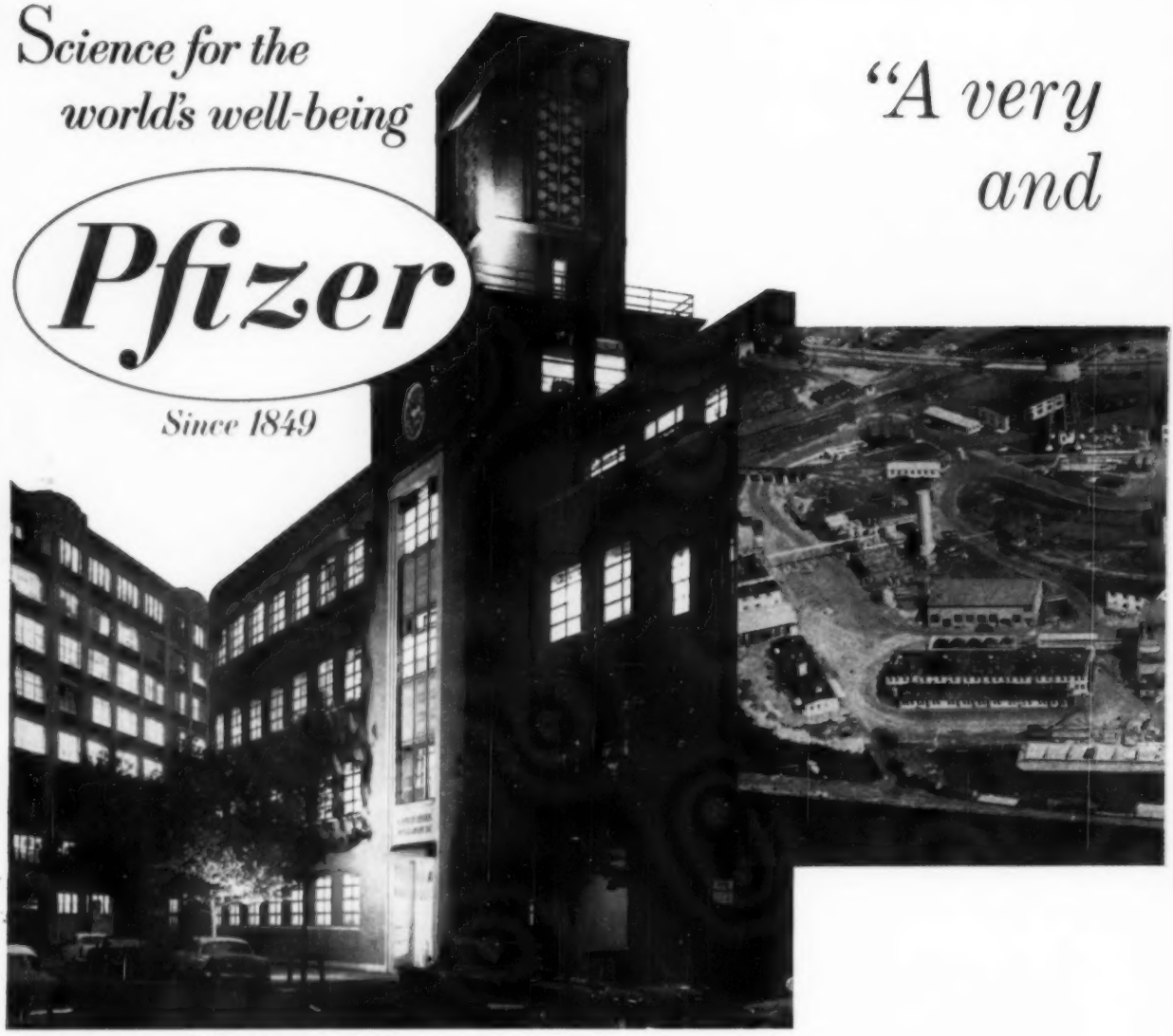
60 East 42nd Street, New York 17, N. Y.

Science for the world's well-being

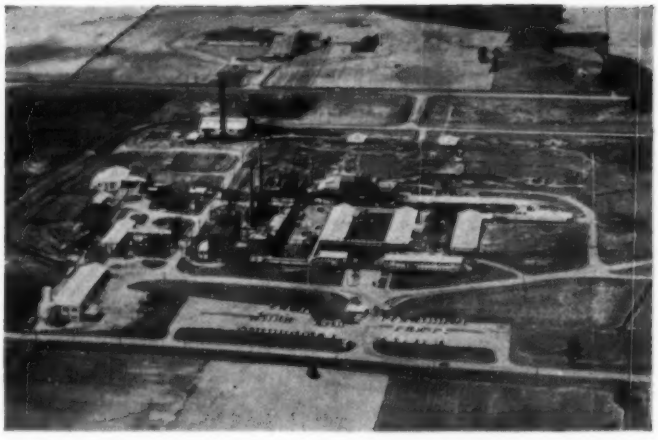
Pfizer

Since 1849

"A very and



Pfizer headquarters: executive offices and research laboratories in Brooklyn, New York. In the associated production plant, a modern Combustion VU-50 Boiler has been meeting essential heat and processing requirements during the past four years by producing 140,000 lbs of steam per hour.

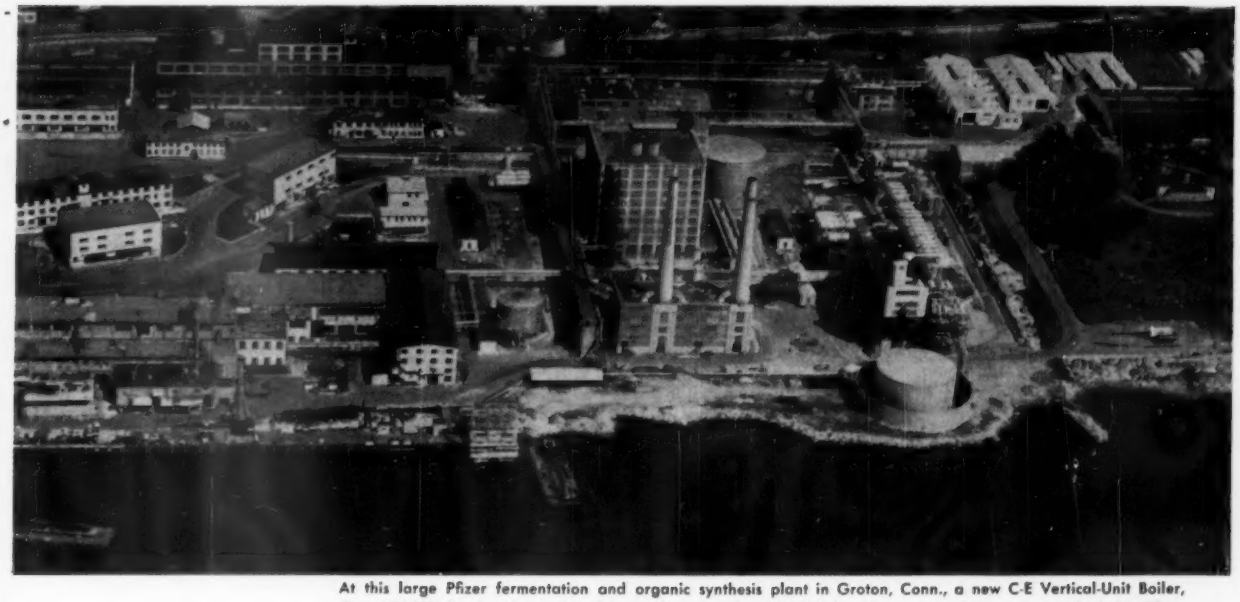


Pfizer's Vigo Plant relies on four Combustion VM Boilers fired by C-E Spreader Stokers for economical heating and processing. Well suited to fill local needs, these units are each rated at 30,000 lbs of steam per hour at an operating pressure of 150 psi. In various Pfizer plants, nine C-E units have a total steam production capability of 740,000 lbs of steam per hour.

ALL TYPES OF STEAM GENERATING, FUEL BURNING AND RELATED EQUIPMENT; NUCLEAR REACTORS;

satisfactory dependable Boiler"

says C. V. Reichelt, Director of Engineering, Chas. Pfizer & Co., Inc.



At this large Pfizer fermentation and organic synthesis plant in Groton, Conn., a new C-E Vertical-Unit Boiler, Type VU-50X, has just been placed on the line. Rated at 165,000 lbs of steam per hour — a new high for Pfizer — it joins three other oil fired C-E boilers, two VU-40 units and one VU-50 unit, already in service at the plant. Each is rated at 115,000 lbs/hr.

When Chas. Pfizer & Co., Inc., recently put into service a new C-E Vertical-Unit Boiler in their Groton, Conn., fermentation and organic synthesis plant, they were capitalizing on long experience. Eight previous C-E units, three of them at Groton, had been producing steam efficiently in Pfizer plants since 1948.

Mr. C. V. Reichelt, Director of Engineering, describes Pfizer's experience with its latest C-E unit as follows: *"The new 165,000 lb/hr boiler . . . is proving to be a very satisfactory and dependable unit. Particular commendation is made of the refinements with regard to air pre-heater and fly ash arrestors which Combustion Engineering included in their design. Special mention is also made of the fine job that was done in getting the boiler on the line on time in spite of a tight schedule for fabrication and erection. This boiler is the fourth and largest C-E boiler installed at our Groton facilities."*

With three other C-E Boilers at Groton, this unit is now producing steam for power and process in the production of the well-known Pfizer antibiotics such as Terramycin as well as for a wide range of pharmaceuticals and chemical and agricultural products.

Pfizer's experience with C-E boilers extends beyond Groton, too. At Terre Haute, Indiana, the company's Vigo Plant uses four Combustion boilers fired by C-E Spreader Stokers; and at the Brooklyn Plant, the company's original "shop", dating back to 1849, another C-E Boiler is entering its fourth year of service.

Today, in more than 100 countries around the world, Pfizer "Science for the world's well-being" contributes to the advance of medicine, agriculture and industry. Combustion Engineering is proud to have a share in this march of scientific progress.

COMBUSTION ENGINEERING

Combustion Engineering Building • 200 Madison Avenue, New York 16, N. Y.

C-231

PAPER MILL EQUIPMENT; PULVERIZERS; FLASH DRYING SYSTEMS; PRESSURE VESSELS; SOIL PIPE

Hall Industrial Water Report

VOLUME 7 SEPTEMBER 1959 NUMBER 5

Air Conditioning Means Water Conditioning

To the layman air conditioning means air cooling—nothing else. But the engineers who must operate large air-conditioning systems know the part that water plays in the condensers, air washers, humidity control and chilled water systems. They know too, that they need help to prevent the troubles with scale, corrosion and biological growths that occur wherever water is used.

Hall engineers are ready to give the help needed. They are trained to tackle the specific water problems encountered in air-conditioning systems, just as they are trained to assist you in making water in all industrial operations behave . . . from the source, on through boilers, service systems and process to final disposal.

Big Trouble With A Small Unit

When a Pennsylvania university installed a small air-conditioning system, operation was begun without water treatment. The water used was corrosive. After seven months copper condenser tubes in the refrigerating unit were pitted and perforated. So were steel condenser water boxes and baffle and the steel recirculating water receiving tank. Estimated cost of repairs was more than $10,000.

After this bad start Hall engineers were called. R. A. Danesi recommended replacement of the ruined copper condenser tubes with tubes made from a more corrosion resistant copper alloy. He also recommended conditioning of the cooling water with polyphosphate and set up rigid control of pH and blowdown. Two inspections during the next year revealed negligible loss of metal.

In this case, operating personnel were not aware of the necessity for water conditioning. Future trouble will be avoided by carefully following recommendations.

Dispersive Stops Scale

A Los Angeles building frequently had to clean heat exchangers in the air-conditioning system. The water, high in temporary hardness, attained a pH of 8.2 to 8.5 and produced calcium carbonate deposits when concentrated only one and one-half to two times. Treatment with the slowly soluble polyphosphate Micromet® largely eliminated the calcium carbonate but the system became dirty with calcium phosphate.

Hall engineer L. Arnold first considered reducing the pH of the water with sulfuric acid to stop the calcium phosphate precipitation. Building operators wanted to feed acid but the money needed to purchase feeding equipment was unavailable.

Arnold's next suggestion was to supplement the Micromet with some Hagan dispersive for minimizing accumulation of the calcium phosphate. This was done, and during the next air-conditioning season the heat exchangers were not once taken out of service for cleaning. When opened at the end of the season, they were found to be cleaner than they had been in the spring.

The Missing Bromide

Hall engineer G. E. Starr received a rush call for help from a southern hospital. Boiler water chloride tests gave results as high as 1000 ppm compared to a normal 100 ppm, even though the continuous blowdown valves were wide open.

The unusual condition set off a systematic search for the source of contamination. Plant testing was checked and found to be satisfactory. Conductivity tests on boiler water samples showed that the contaminant made up the major portion of the dissolved solids. This led the search to the zeolite softener used to treat makeup water for the boilers. No salt contamination of treated water was found.

The only place left to check was the condensate, which was found to be badly contaminated. A check of all sources of condensate ended at the absorption refrigeration machine where lithium bromide—not chloride—was leaking into the steam coils in the generator. The bromide was showing up in the chloride test.

Immediate repair of the leak not only stopped the contamination of the boiler water, but also the loss of expensive lithium bromide.

Absorption Refrigeration Machines

Absorption systems are very sensitive to scale. Temperature differentials across the condenser are not very great to begin with, and heat transfer falls off markedly as deposits accumulate in the condenser.

Formation of deposits is encouraged by the fact that the controls respond to light loads by reducing the flow of water through the condenser, rather than by cutting back the supply of steam to the generator. Water temperature rises and the formation of deposits is accelerated.

Serious corrosion of tube sheets in condensers and absorbers can occur because of galvanic action between copper tubes and steel tube sheets. Two methods of tackling this problem are to use corrosion resistant alloys for fabrication of tube sheets or to coat tube sheets with protective coatings. In addition, water conditions must be carefully controlled.

All of this points to the importance of water conditioning for uninterrupted operation. Engineers skilled in this work can be of real help to you.

Industrial Water Problems Require Special Handling

There are no "stock answers" to industrial water problems. For information on how the Hall System can help you solve your particular water problems write, wire or call address below.

Water is your industry's most important raw material. Use it wisely.

HALL LABORATORIES
DIVISION OF HAGAN CHEMICALS & CONTROLS, INC.
HAGAN BUILDING, PITTSBURGH 30, PA.
In Canada: Hagan Corporation (Canada) Limited, Toronto

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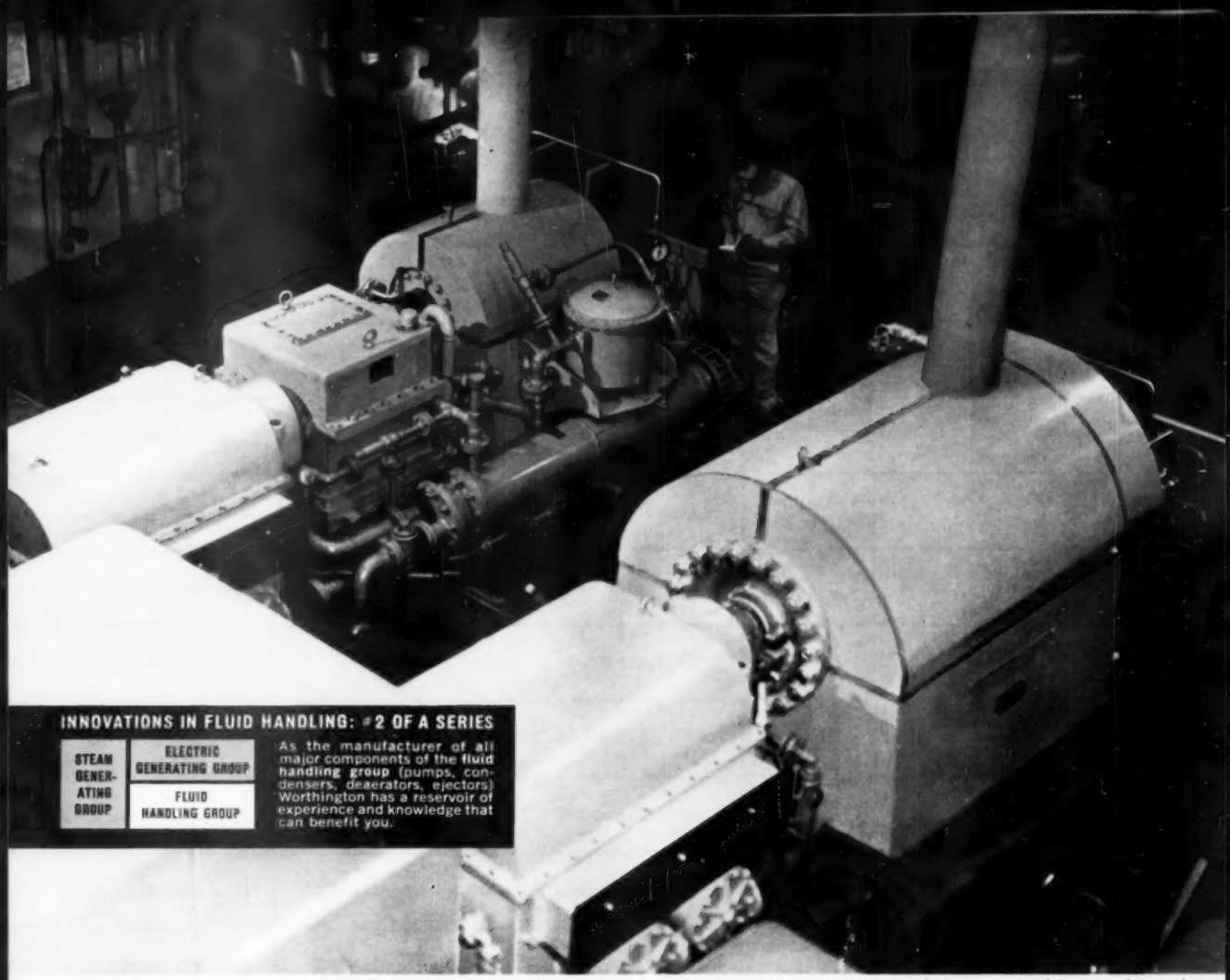
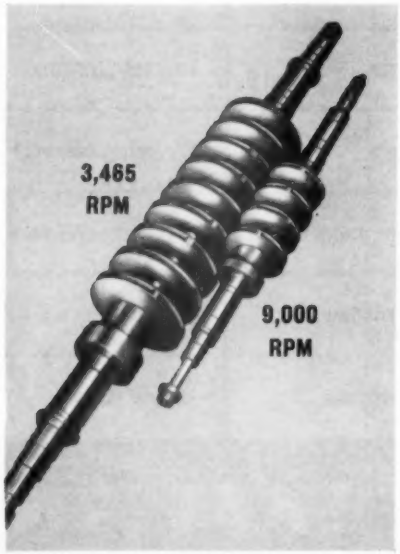

INNOVATIONS IN FLUID HANDLING: #2 OF A SERIES
STEAM GENERATING GROUP
ELECTRIC GENERATING GROUP
FLUID HANDLING GROUP
As the manufacturer of all major components of the fluid handling group (pumps, condensers, deaerators, ejectors) Worthington has a reservoir of experience and knowledge that can benefit you.

This photo measures pump progress. Here are two boiler feed pumps with duplicate pressure and capacity ratings. On the right is a unit of conventional speed; the other is the fastest pump of its type in service, running at 9,000 rpm. Smaller size is dramatically evident.



Comparison of rotors. The rotors used in the two pumps above are shown here. The 4-stage rotor used in the high speed pump will have one-third the deflection of the 9-stage rotor in the conventional unit.

PUMP PARADOX

High speed boiler feed pumps are several times as fast, yet actually more reliable

In modern power plants, the demand for higher efficiency has led to higher operating pressures and, therefore, higher heads for boiler feed pumps. This is a critical area for the fluid handling group. Can you obtain these higher heads without sacrificing reliability?

Worthington has proved that you can. By going to speeds twice as fast (and even greater) Worthington drastically reduces shaft spans required. This cuts shaft deflection to a fraction of its former value. Since pump wear, and hence pump life, is directly related to shaft deflection, the high speed pump is actually more reliable than a conventional unit of the same capacity.

Experience in the field has proved the wisdom of Worthington's design philosophy. More than 39 Worthington high speed pumps are now installed and 21 are on order. Speeds range from 6,500 to 9,000 rpm. If necessary, Worthington sees no reason why speeds shouldn't go even higher, without departing from experience-proved construction principles.

Reducing shaft deflection through shorter shaft span is only one way that Worthington increases boiler feed pump reliability. Other ways include larger shaft diameters, liberal clearances, shrunk on impellers, metal-to-metal pressure joints, a special method for measuring internal wear, and anti-oil-whip bearings.

High speed boiler feed pumps are one example of Worthington's leadership in the fluid handling area. Through the years Worthington has made many contributions to the solution of power plant problems. Why not put this progressive "know how" to work on your next plant? Worthington Corp., Harrison, N. J. In Canada: Worthington (Canada) Ltd., Brantford, Ontario.

"45-14"

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Ready for any fuel job

Name of Coal	Character	Mine	Seam	County & State
Sonman	Central Pennsylvania Low Volatile	Sonman	"E"	Cambria (Pa.)
Colver		Colver	"B"	Cambria (Pa.)
Indian Creek	Central Pennsylvania Medium Volatile	Melcroft	"B" or Miller	Fayette (Pa.)
Federal	Northern West Virginia	Federal #1	Pittsburgh	Marion (W. Va.)
Beckley	Southern West Virginia Low Volatile	Eccles #5	Beckley	Raleigh (W. Va.)
Sewell		Eccles #6	Sewell	Raleigh (W. Va.)
New River		Stotesbury #8	Pocahontas #4	Raleigh (W. Va.)
		Stotesbury #10	Pocahontas #4	Raleigh (W. Va.)
		Stotesbury #11	Pocahontas #4	Raleigh (W. Va.)
Pocahontas		Keystone	Pocahontas #3	McDowell (W. Va.)
Eagle	Southern West Virginia and Eastern Kentucky High Volatile	Beards Fork	Eagle	Fayette (W. Va.)
		Kopperston #1	Eagle	Wyoming (W. Va.)
No. 2 Gas		Kopperston #2	Campbells Creek	Wyoming (W. Va.)
Wharton		Wharton #1	Hernshaw	Boone (W. Va.)
		Wharton #2	Hernshaw	Boone (W. Va.)

The comprehensive line of Beacon Coal provides a fuel exactly suited to every application: Domestic or Commercial Hand or Stoker firing; General Industrial; Electric Utility; Railroad; Coke and Gas Plants; and special uses. Mine locations and shipping facilities permit speedy, efficient distribution. And conveniently located sales offices mean that there's a Beacon Representative nearby, ready to help fill your coal needs.

EASTERN GAS AND FUEL ASSOCIATES
BEACON COAL

EASTERN

PITTSBURGH · BOSTON

This convenient Reference Chart shows why!

Railroad	District	Sizes Made	Daily Prod. Tons	Name of Coal
Penna.	1	Egg; Stoker; M/R; N&S; Slack	2500	Sonman
C & I	1	N&S; Slack; Stoker; Nut	5000	Colver
B & O	1	M/R; N&S; Slack	1200	Indian Creek
Monongahela; B&O	3	Lump; Egg; Nut; Stoker; M/R N&S; Slack	12,500	Federal
C&O; Virginian	7	Scr. M/R; Stove; N&S; Slack	2500	Beckley
C&O; Virginian	7	Scr. M/R; Stove; N&S; Slack	1000	Sewell
C&O; Virginian	7	Stoker; M/R; Slack	2000	New River
C&O; Virginian	7	Stoker; N&S; Slack	2500	
Virginian	7	M/R; Slack	1800	
N & W	7	Egg; Stove; Nut; Stoker; M/R; N&S; Slack	7500	Pocahontas
Virginian	7	M/R; N&S	2900	Eagle
Virginian	8	M/R; N&S; Slack	3500	
Virginian	8	M/R; Nut; N&S; Slack	7000	No. 2 Gas
C & O	8	M/R; N&S	3500	Wharton
C & O	8	M/R; N&S	4000	

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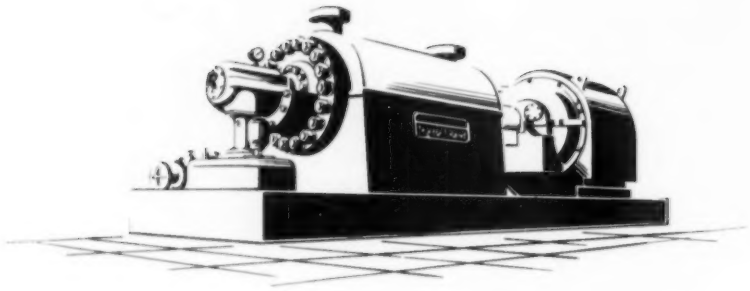
For New England: New England Coal & Coke Company For Export: Castner, Curran & Bullitt, Inc.



superlatives

that demonstrate confidence in a high-pressure boiler-feed pump and its builder

LARGEST CAPACITY ..... *7200 gpm.* Two record-breaking 7200-gpm pumps with discharge pressure of 4550 psig, for two 450,000-kw generating units.

HIGHEST PRESSURE ..... *6500 psig.* Two half-capacity units, each consisting of three pumps in series, with discharge pressure of 6500 psig, for a 325,000-kw station.

HIGHEST HORSEPOWER ..... *23,000 hp.* Two large capacity, high-head pumps, each driven by a 23,000-hp steam turbine, largest ever built for boiler-feed service.

LARGEST GENERATING UNIT ..... *500,000 kw.* Two turbine driven half-capacity pumps, each handling 4000 gpm at 3108 psig discharge, at 6600 rpm for world's first half-million kw generating unit.

GREATEST ACCEPTANCE ..... *Ingersoll-Rand* has built far more high-pressure boiler-feed pumps than any other manufacturer — including many *high-speed* units for generating stations. These superlatives demonstrate industry's confidence in I-R Class CHTA pumps, and in Ingersoll-Rand's ability to design and build to any requirements — even those that go beyond previous industry experience. For maximum dependability and long-range economy, specify boiler-feed pumps by Ingersoll-Rand.

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At the Wood River Station of the Illinois Power Company, Diamond's "Utiliscope" Television system has provided 100% available viewing since 1949. In this job, dependability is all important! Only Diamond builds the tube which makes this availability possible.

The operator, in the control room, sees the boiler water level at the drum by viewing the Diamond monitor mounted in the control panel. Water level information is instantly and accurately available at all times from any viewing position in the control room.

Routine maintenance is the only service required since installation. "Old Reliable" has a record of more than ten years of operation and is continuing to provide reliable service.

Such performance is not unusual for Diamond's "Utiliscope" equipment. This Heavy Duty Television is designed for industry. It is dependable, durable, resistant to time and difficult operating conditions. It is saving money and improving operation in power plants, steel mills, foundries, mines and a wide variety of manufacturing plants.

Write us for a non-obligating survey of your plant by our industrial television specialists. Electronics Division, Diamond Power Specialty Corporation, Lancaster, Ohio.

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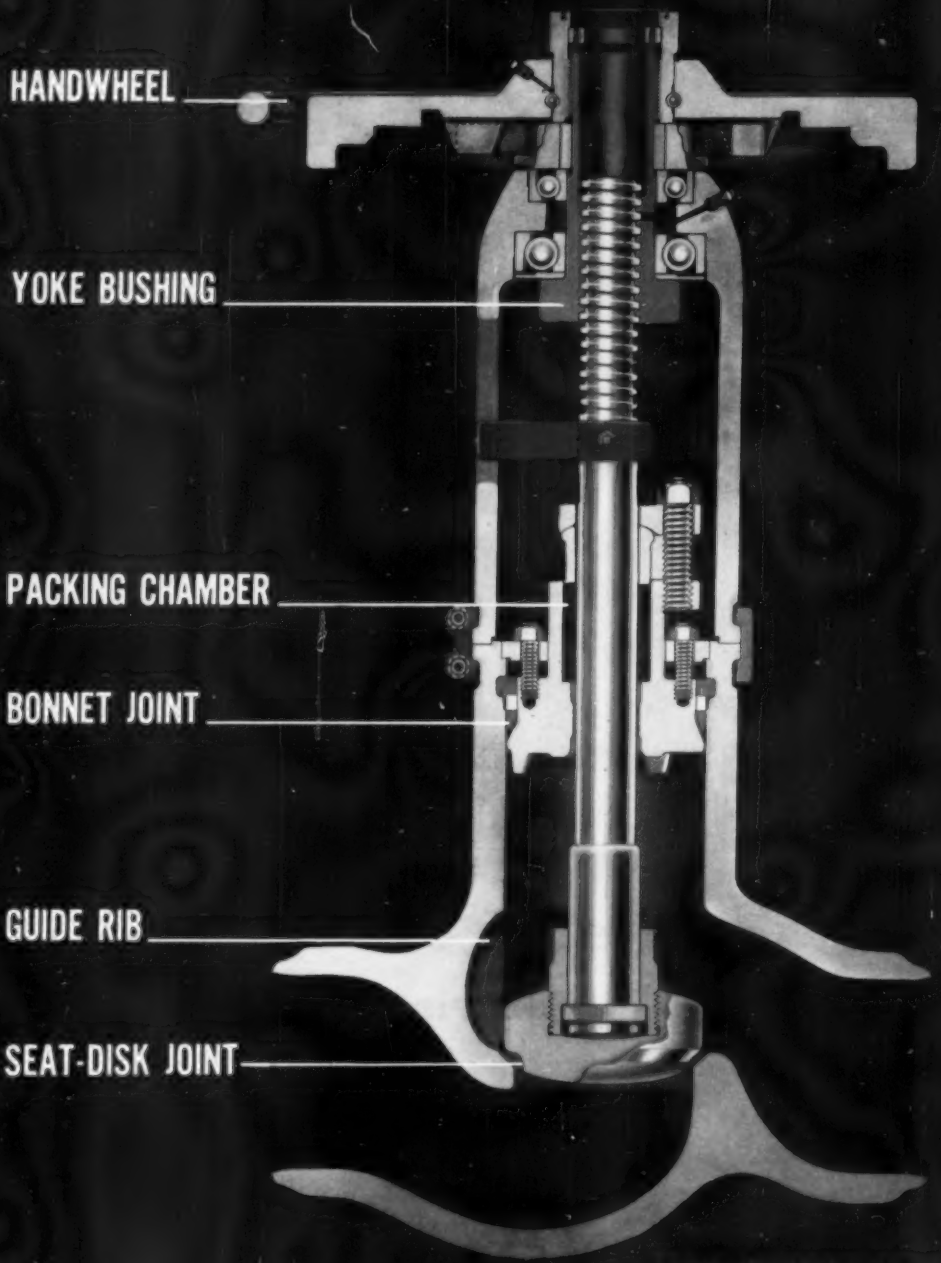
Diamond

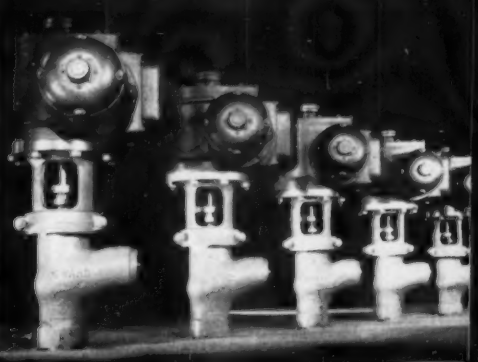
DIAMOND POWER SPECIALTY CORP.
LANCASTER, OHIO *Diamond Specialty Limited, Windsor, Ontario*



EDWARD CAST STEEL
GLOBE VALVE FIG. 4016Y

IMPACTOGEAR® OPERATED VALVE ←

→ MOTOR OPERATED VALVES



What's New from Edward Valves

New Products . . . Solutions to Problems . . . Information on Steel Valves from Edward, Long-Time Pioneer in the Field!

HOW TO SELECT CAST STEEL VALVES

Valves for today's high-pressure processes require economy, dependability and safety in operation. The material on these pages is designed to help acquaint you with a few basic principles and features you should consider when selecting cast steel valves 2½ inches and larger.

VALVE FEATURES FOR LONGER LIFE, EASIER OPERATION

Valve Handwheel should be large enough to operate valve easily. On smaller valve sizes, a knobbed handwheel design permits tighter grip. But for larger, high-pressure valves, impact-type handwheels will increase closing force, insure tighter closure (see large illustration opposite page). Quick closing can be obtained with impact-type handwheels geared for closing with the aid of portable air or electric wrenches (bottom-left, opposite page). Or, where central or automatic control is desired, consider fixed motor operation (bottom-right, opposite page).

Yoke Bushing on larger valves in higher pressure classes should be equipped with double ball-bearing construction for reduced operating torque and effective transmission of closing load (large illustration on opposite page shows this design). Material is important, too. On smaller valves, bushings of bronze will help prevent stem seizing or galling. Look for ample thread engagement between bushing and yoke and between bushing and stem.

Packing Chamber should be large enough to insure long packing life. Valve packing must allow the stem to move within the bonnet but must not allow any fluid leaks between them. Well made packing, formed specifically for the packing chamber and correctly compounded for your pressure-temperature service conditions, has much to do with satisfactory valve performance. Valves with a positive backseat for re-packing while under pressure offer additional operating advantages.

Bonnet Joint of bolted construction (see Fig. 618 this page) is easiest to work with on medium or small size valves. But for lasting bonnet joint tightness, in high-temperature services (and for reduced size and weight), pressure-seal bonnet joint design is best—no flanges or bolting to periodically restress (see large illustration opposite page). Not all pressure-seal designs are alike, however. Avoid gaskets with small sealing surfaces and sharp edges that can be easily damaged and large threaded gasket loading mechanisms that are hard to disassemble and give unknown gasket compression.

Disk Guiding that properly centers the disk into the seat for positive shut-off regardless of position is important. Valve bodies with integrally cast guide ribs supporting disk throughout travel are best. Avoid designs which attempt to guide by installing spider in seat opening.

Seat-Disk Joint—An integral hard-faced seat is generally regarded as superior to screwed seat construction because it eliminates body-seat leakage and retains hardness under temperature. A hard-faced disk or disk of special alloy is desirable in high temperature services; but 13 per cent chromium stainless steel is an excellent all purpose material below 750° F.

Body Design with streamlined flow passage areas (opposite page) reduces wear-producing turbulence, decreases pressure drop and delivers maximum flow. Valves with streamlined body contours will often permit the use of smaller pipe and valve sizes. Angle valves (see Fig. 7517Y, upper right) have even less pressure drop.

For more detailed information, contact your Edward Representative, or write Edward Valves, Inc., 1206 West 145th Street, East Chicago, Indiana. Subsidiary of Rockwell Manufacturing Company. Represented in Canada by Lytle Engineering Specialties, Ltd., 360 Notre Dame Street, W., Montreal 1, Quebec.

Edward Valves builds a complete line of cast steel stop, check, non-return, stop-check and gate valves for pressures to 10,000 lbs. available with flanged or welding ends. Below are illustrated a few of the major valve designs from this complete line.

Fig. 7517Y
Angle stop valve, 1500 lb at 850 F. (3600 lb WOG), with integral Stellite seat, Stellited disk, pressure-seal bonnet, welding ends. 2½" to 14".

Fig. 618
Globe stop valve, 600 lb at 850 F. (1440 lb WOG), bolted bonnet, flanged ends, integral Stellite seat, Stellited disk. Sizes 2½" to 6".

Fig. 607Y
Angle non-return valve, 600 lb at 850 F. (1400 lb WOG), with pressure-seal bonnet, integral Stellite seat, Stellited disk-piston, welding ends, sizes 8" to 14".

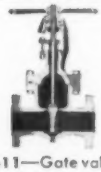


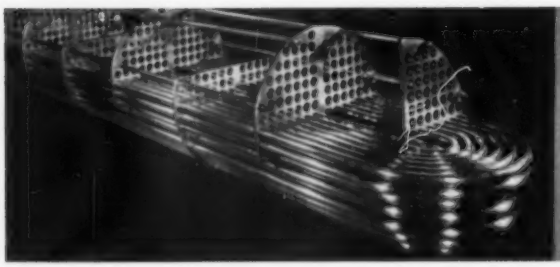
Fig. 611—Gate valve, 600 lb at 850 F. (1440 lb WOG), with hard-surfaced seats and wedge, ball bearing yoke, flanged ends. Sizes 2½" to 12".

Fig. 4094Y—Horizontal check valve, 900 lb at 850 F. (2160 lb WOG), with integral Stellite seat, Stellited disk-piston, pressure-seal cover, welding ends. Sizes 2½" to 14".

Fig. 7514—Flite-Flow globe stop valve, 1500 lb at 850 F. (3600 lb WOG) or 2500 lb at 850 F. (6000 lb WOG), with extremely low pressure drop and other premium features. Sizes 10" to 18".

EDWARD STEEL VALVES
another fine product by
ROCKWELL

Catalog 14 contains full data on the complete Edward line of forged and cast steel valves from ¼" to 18"; in globe and angle stop, gate, non-return, check, blow-off, stop-check, relief, hydraulic, instrument, gage and special designs; for pressures up to 10,000 lbs: with pressure-seal, bolted, union or welded bonnets, with screwed, welding or flanged ends.



CONDENSER AND HEAT EXCHANGER CLINIC

Edited by David S. Hibbard, Metallurgical Engineer
The American Brass Company, Buffalo 5, New York

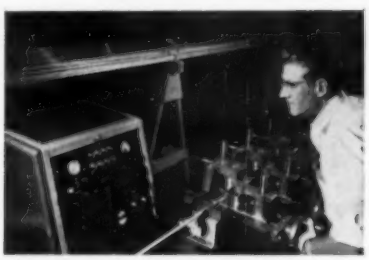
New controls and services meet increasingly critical requirements in heat-transfer units

As steam cycles in turbines become more complex—and operating temperatures and pressures rise—the job of the heat-transfer equipment becomes increasingly critical. Nuclear energy plants place tremendous emphasis on continuity of service for even conventional components like condensers. And in many processing plants the cost of shutdowns may range from exorbitant to disastrous.

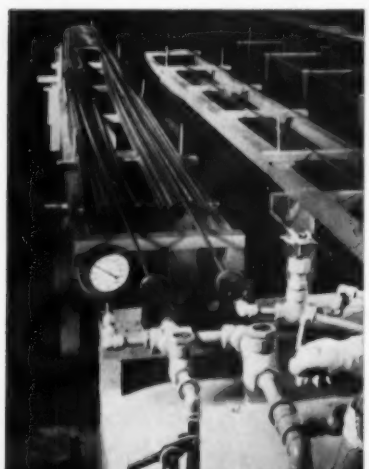
Assurance that tubes will meet service requirements becomes increasingly important. And The American Brass Company has augmented its normal quality controls with tests and services to help makers of heat transfer equipment prevent possible trouble before it starts.

Electronic inspection. All tubes are inspected visually one at a time, both internally and externally. However, where greater assurance is required, the tubes—in straight lengths up to 100′—can be inspected electronically by eddy-current equipment.

All tubes are inspected visually one at a time, both externally and internally.



When required, tubes are inspected by eddy-current equipment, located at the tube straightener.



All U-bend tubes are tested hydrostatically at ASME Code pressures—or higher, if necessary.

Hydrostatic testing. As most U-bend tubes are used in applications involving high temperatures and pressures, all of these tubes are tested hydrostatically—after bending—at ASTM Specification pressures. They can, however, be tested at ASME Code pressures, up to 6000 psi, on request, if the tube size is such that it will withstand the pressure.

Relieving stresses. All U-bend tubes, other than copper, are annealed at the bend area after bending, to eliminate the hazard of stress-corrosion cracking which might occur in service due to stresses that may exist as a result of the bending.

Duplex tubes are widely used in chemical plants and petroleum refineries to meet diverse combinations of corrosive action and/or pressure and temperature. Recently designers have selected them for use in air-removal sections of electric-power-plant condensers where corrosion is very severe.

Broadest service. In helping manufacturers and users of heat-transfer equipment meet day-to-day problems, The American Brass Company has a broad background in the latest developments in heat-transfer equipment's expanding role. And with new mill equipment now in place, it offers the broadest service available in tubes for heat-transfer equipment. For technical assistance in special problems, write: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont. 8958 Rev.

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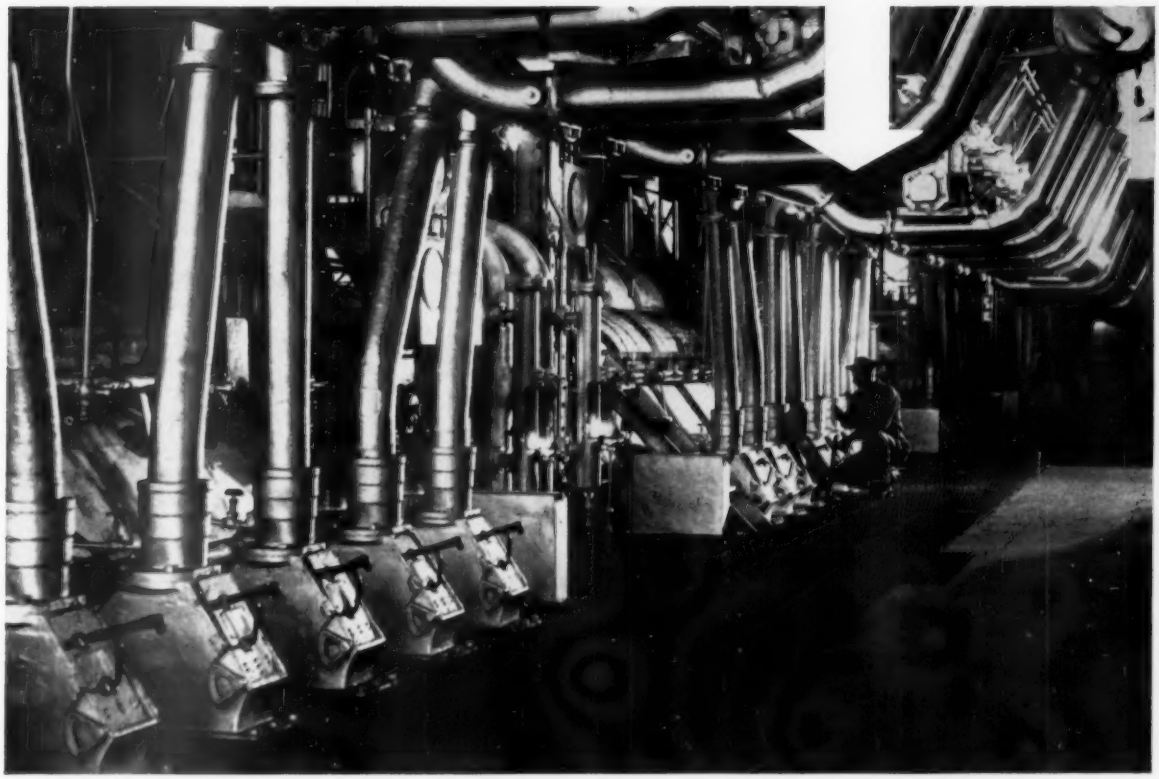

One of our famous Valley Camp Quality Coals, crushed, washed, sized and thermally dried, mixed to your specifications, can bring real savings in your steam costs . . . in your present burning equipment.

Our combustion engineering service will be pleased to discuss the details with your power engineers.

THE VALLEY CAMP COAL COMPANY

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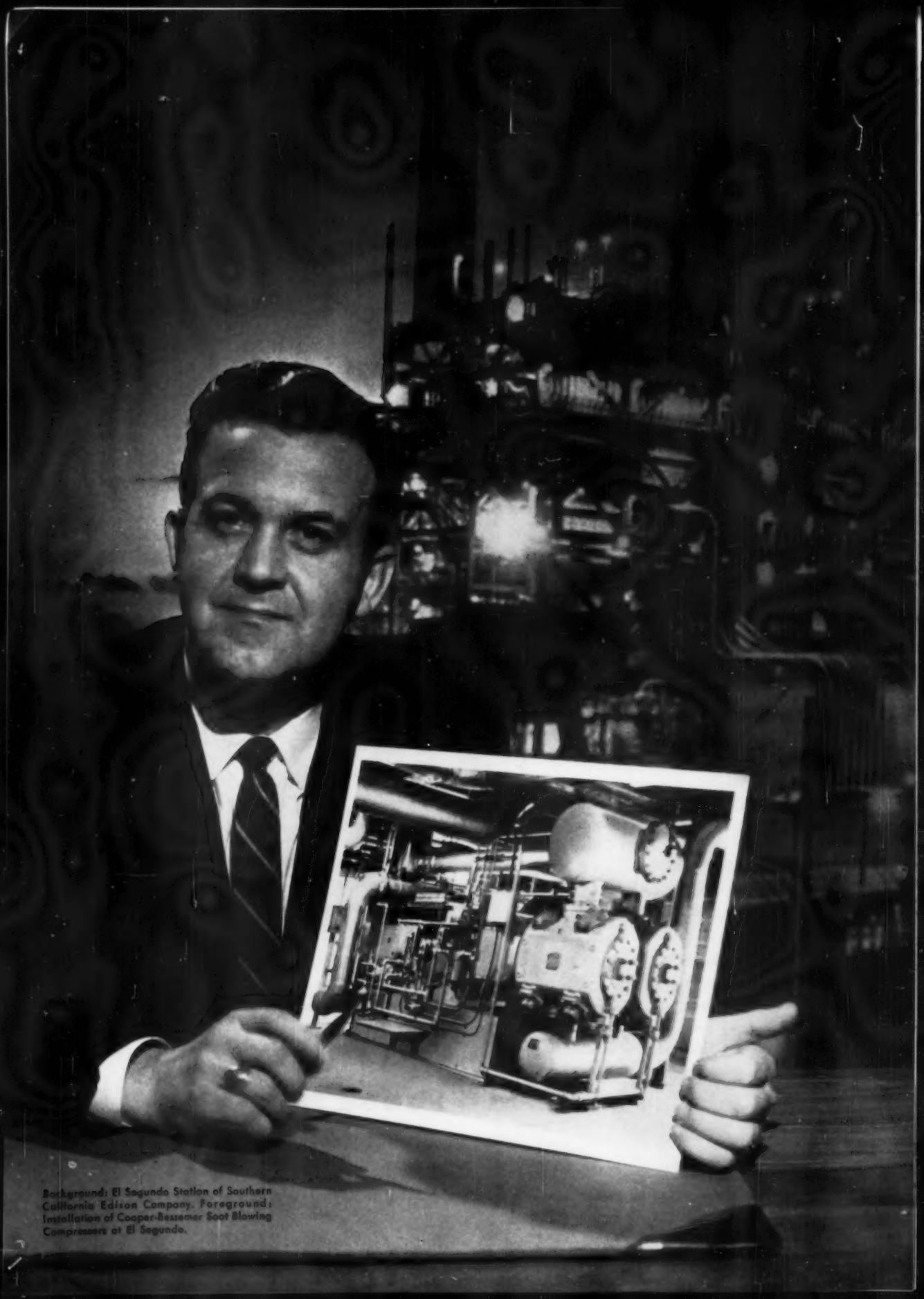

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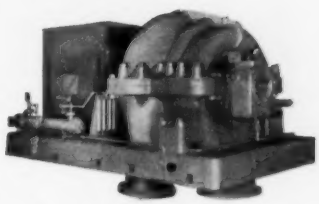

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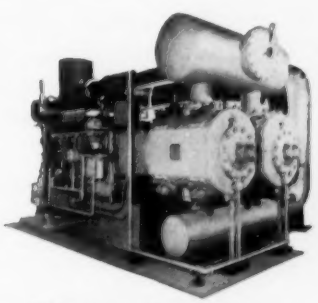

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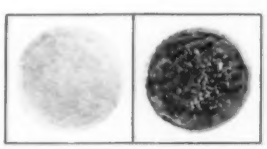

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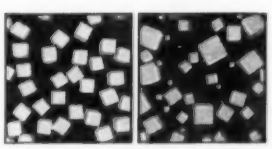

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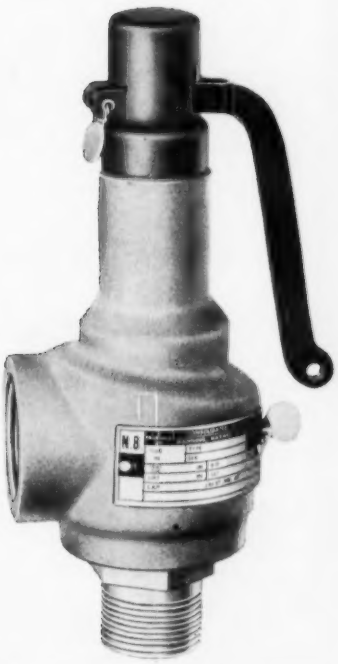

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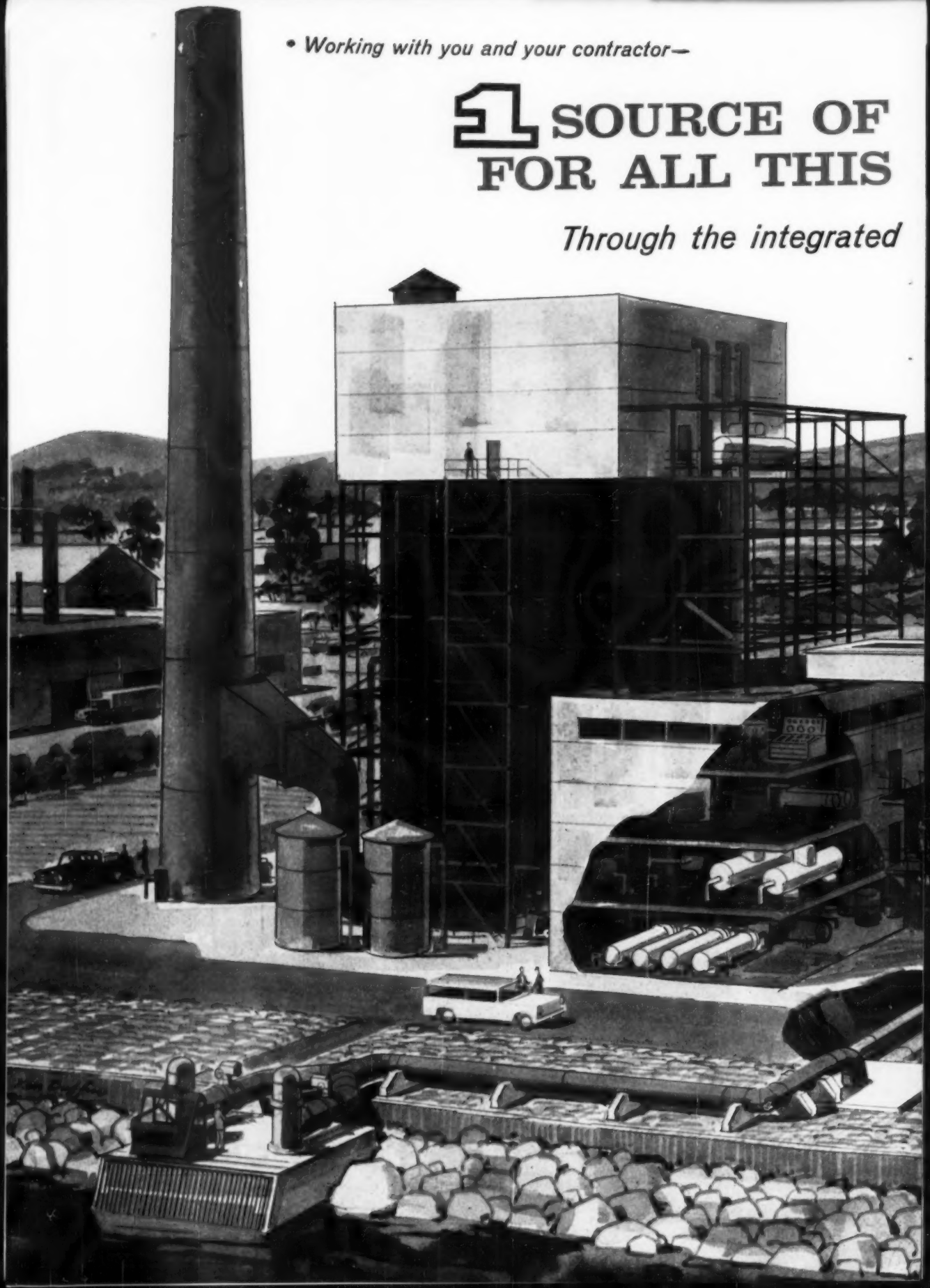

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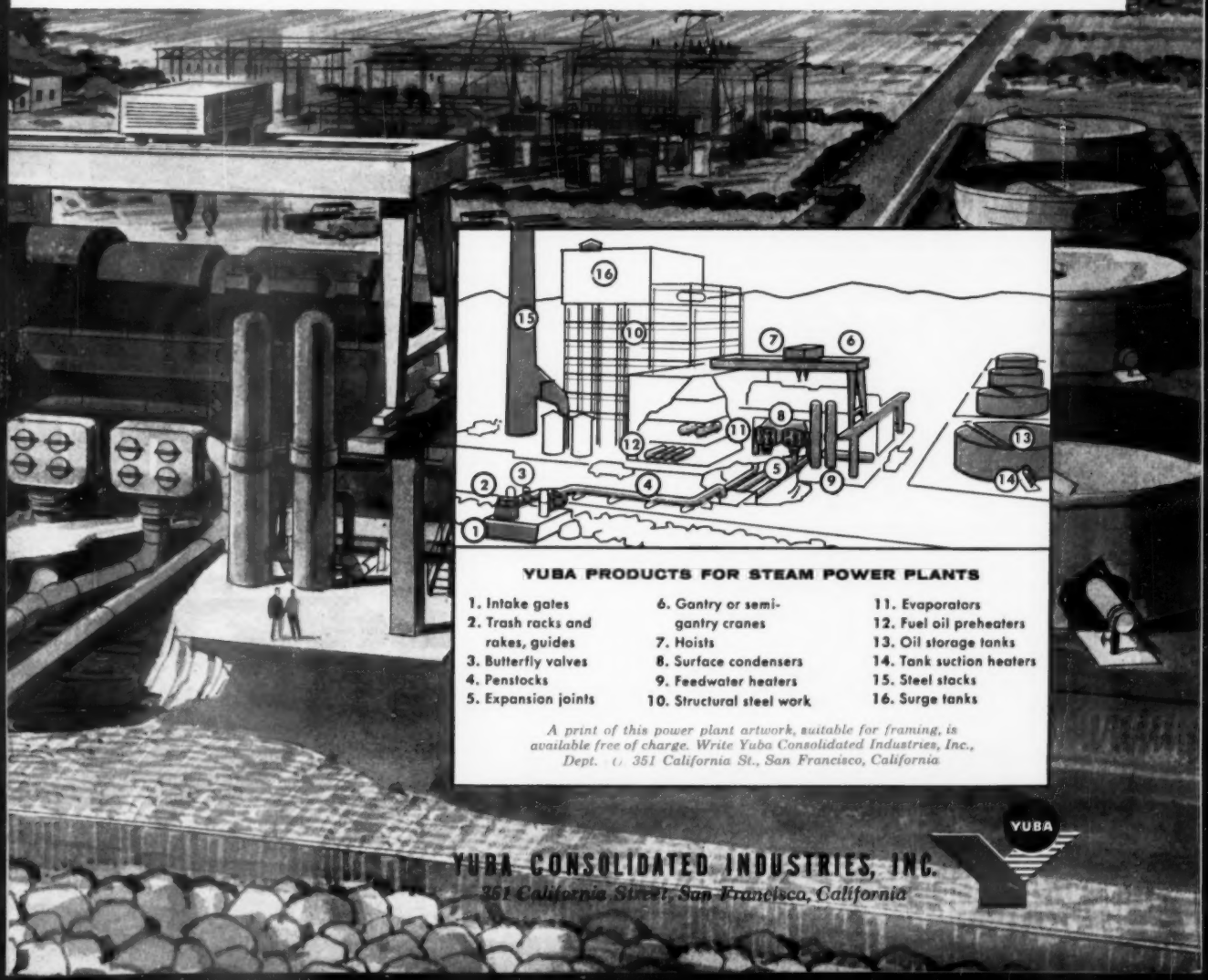

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MgO	2.00
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SO_3	3.07
Alkalies + Combined Water + Undetermined	0.49
	100.00%

Fusion Temperature of Ash Dundon Coal

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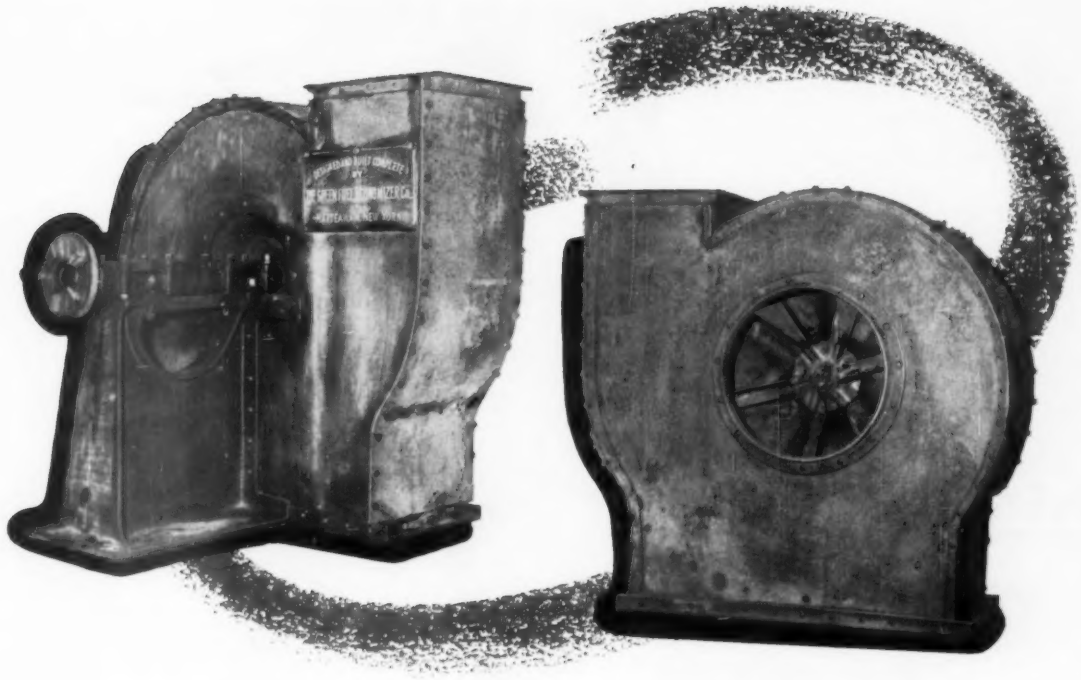

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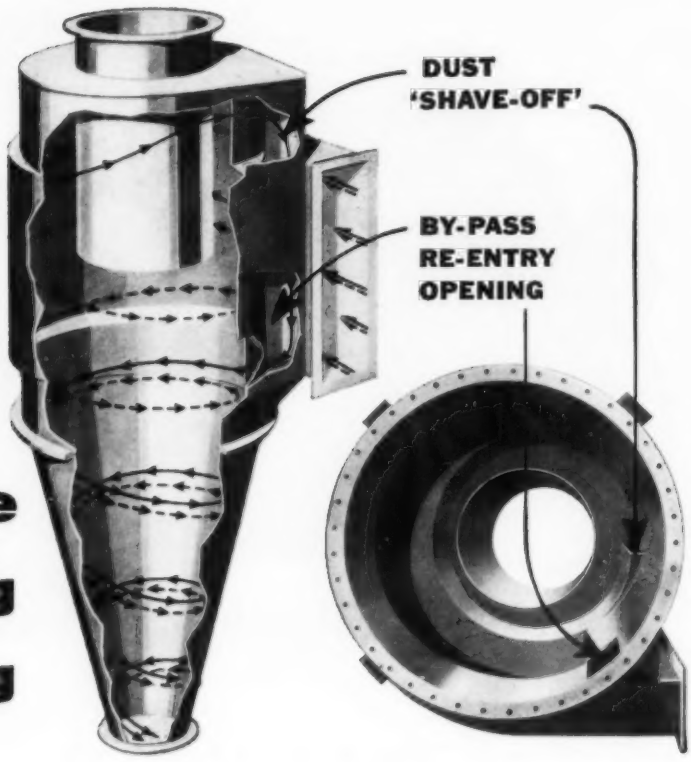

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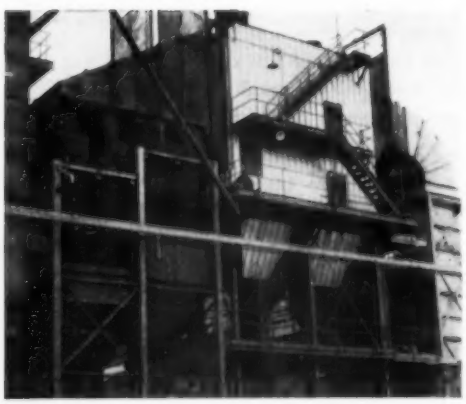

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Editorial

The Fuel Glut

At the American Mining Congress in Cincinnati in May of 1958 John L. Lewis, who not too long before was held to be the one most likely to rock the coal industry's boat, called upon the producers, the operators, the utilities, the coal-carrying railroads as well as his own United Mine Workers of America to join forces so the coal industry could speak with one voice. The purpose of this voice-in-unison was to impress upon the federal government a need for a national fuel policy. Out of this plea for one voice came the National Coal Policy Conference whose president is Joseph E. Moody, also president of the Southern Coal Producers' Association.

On July 2 of this year Mr. Moody appeared before the Subcommittee on Mines and Mining of the House Interior and Insular Affairs Committee. His point in a sentence: "We are convinced that it is imperative that a national fuels policy be drafted and put into operation without delay." The principal cause for the conviction Mr. Moody expressed is the same one so ably advanced by Philip Sporn in a lecture before the Supply Section of the Institute of Electrical Engineers, in London, England, five or so years ago. We quote:

"One danger which is facing the American power industry may come about as a result of the coal industry's subjection to very difficult competitive forces over the next decade, and then perhaps being asked at the end of that time, after a protracted condition of relative starvation to pick up and do a giant's job in a national emergency."

The competitive forces Mr. Sporn alluded to in 1954 have become immeasurably stronger with the opening of the Sahara and Libyan desert oil fields. At this writing these fields give promise of tremendous outputs, lighter in gravity than domestic, Venezuelan, or Middle Eastern oils and hence more fitted to gasoline production than fuel oil. Yet available in such quantities that the fuel oil market will prove an attractive one. In addition, we are told, the Rumanian and the Russian oil refiners are looking toward markets beyond Europe within a few years. The U. S. market is more or less sealed off to this flood of oil by import quotas as one observer points out. But the Western European market, comprising the heart of the NATO membership, is wide open. What effect could this fuel glut have on "the giant's job" Mr. Sporn saw as a danger to the American power industry?

Reports indicate coal miners are being let go in many of the European countries. With more oil available than markets for it our European friends may very well elect to reap the immediate advantages of an oil price war and let their traditional native coal sources go to pot. Will we be expected to have in readiness a fuel reservoir to meet their needs in addition to our own in event of a world emergency? Can we reconcile for very much longer our very largely laissez faire fuel supply and marketing picture with our position as the expected bulwark of the NATO? We for one feel we cannot and must add our endorsement to Mr. Moody's statement, "We are convinced that it is imperative that a national fuels policy be drafted and put into operation without delay."

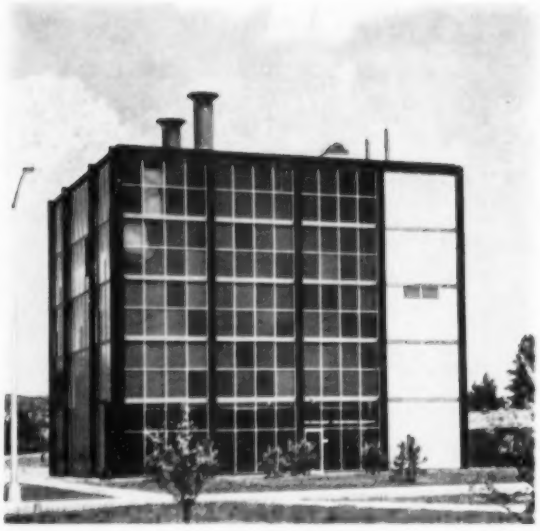


Fig. 1—Service and air field area central heating plant

Interesting and complex problems face the designer of a heat production and transmission system able to serve a large project with widely varied requirements. The High Temperature Hot Water installation at the U. S. Air Force Academy is just such a project. Mr. Hansen's detailed analysis and evaluation shows how and why HTHW district heating was applied to achieve low capital and operating costs. The first elements of this system were started up in the fall of 1957.

By E. G. HANSEN†

J. O. Ross Engineering—Division Midland-Ross Corp.

HTHW District Heating At The U. S. Air Force Academy*

THE U. S. Air Force Academy near Colorado Springs is a project of immense size. It is at one and the same time a University, a Military Base and a complete and self-contained city. It provides all the facilities and services associated with any of the three elements, all of which had to be created from nothing on what before was ranch and forest land.

It is peopled not only by the cadets themselves, who presently number 1575, but whose future enrollment will eventually reach 2550; it also harbors the thousands of people required for training and teaching the cadets, for looking after their welfare and for operating and maintaining the Academy facilities, including the wives and children of all these.

The Heating System for this complex has to be economical and efficient. Special problems were encountered in its design resulting mainly from the distances and the nature of the terrain.

It is the object of this paper to describe the major problems, design concepts and features which may be highlighted as follows:

1. An economic analysis preceding the design indicated: (*a*) That two gas-fired HTHW central plants and district heating systems should be provided for heating all buildings. (*b*) That individual family housing units should have their own gas fired heat sources and should not be connected to the district heating systems.

2. The main HTHW district heating system has a capacity of 400,000,000 Btu/hr (presently installed boiler capacity 300,000,000 Btu/hr), a maximum radius of distribution of 3 to $3^1/_2$ miles. Highest point in distribution system is situated 250 ft above, lowest 250 ft below boiler house floor. The HTHW is generated at 454 F and 440 psia. A separate 60,000,000 Btu/hr HTHW plant serves the Service and Airfield areas.

3. Steam pressurization is used. The boilers are of the LaMont type. Circulation through them is maintained by a separate group of pumps.

Description of Site

The site of the U. S. Air Force Academy is located in the foothills of the Rampart Mountain Range, approximately ten miles north of the city of Colorado Springs, and comprises an area of some 17,900 acres of hilly terrain.

The area is dissected by valleys, ravines and ridges running generally in a west-easterly direction from the foot of the mountain range down toward the plain. Elevational differences between ridges and floors of adjacent valleys vary from 100 to 300 ft.

A narrow strip of the plain is contained within the boundaries of the site and houses the supporting services area and, in the future, also a proposed airfield.

The distance between the extreme developed areas is

† Manager—Supertherm Department

* Presented before the National District Heating Assoc., 50th Annual Convention, June 1–4, 1959.

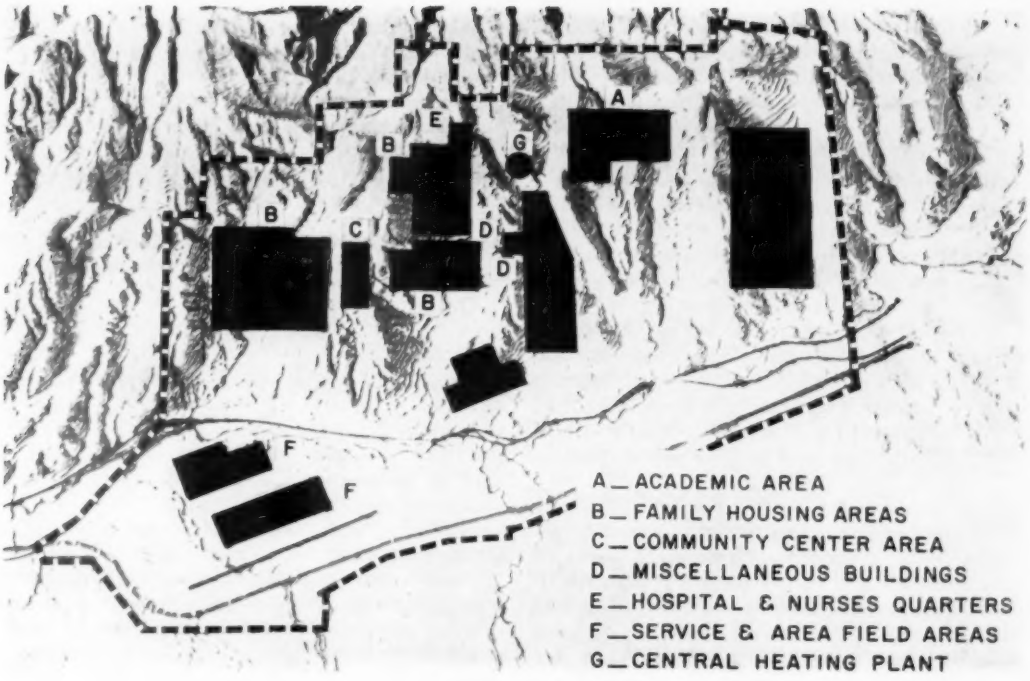


Fig. 2—Relief model of site

approximately 6 miles and the difference in elevation 800 to 850 ft.

Fig. 2 is a photograph of a relief model of the site showing the nature of the terrain and the different developed areas. Below these areas are spelled out and keyed by letter to Fig. 2:

(*A*) Academic Area at an elevation of 7200 to 7250 ft where the cadets live and are schooled.
(*B*) Family Housing Areas.
(*C*) Community Center Area quartering the supporting personnel and the Base Exchange.
(*D*) Miscellaneous buildings making up the Staff Officers' Quarters Area and Neighborhood Schools.
(*E*) Hospital and Nurses Quarters.
(*F*) Service and Air Field Areas at 6400 to 6530 ft where the various utility shops and administrative offices are located.

The various areas are connected by a system of primary and secondary roads.

Heating Loads

In winter, heat is used principally for space heating and ventilation. In summer, air conditioning employing absorption type refrigeration replaces the space heating loads in the Academic Area. Heating of domestic hot water and generating process steam for use in the kitchens and laboratories is a minor all year round load.

The thermal flywheel properties of the heat carrying medium are taken into account for those areas served by the Central high temperature hot water scheme, and the following diversity factors are employed.

Academic Area—85%
Hospital—100%
Community Center Area and miscellaneous buildings—90%
All process steam—65%
Service, Supply and Air Field Area—100%. (A 100% diversity was adopted when designing the HTHW System for the Service and Air Field Area on account of the uncertain future expansion program.)

Using these diversities, the approximate peak requirements used in the design of the distributing system are:

Academic Area—255,000,000 Btu/hr
Hospital—13,500,00 Btu/hr
Community Center Area, including miscellaneous buildings—60,000,000 Btu/hr
Services and Air Field Area—54,000,000 Btu/hr
Housing Areas—135,000,000 Btu/hr

Initial heat requirements in the Academic Area, the Hospital and the Community Center Area are approximately 75 per cent of the ultimate total, and in the Services and Air Field Area the present requirements are approximately 45 per cent.

The above heating loads are peak loads. They are subject to rapid and extreme changes due to climatic conditions and the nature of the building construction.

The climate is very dry, and the sky usually cloudless. At the elevation of some 7000 feet solar irradiation is very

intense; therefore, after a very cold night a strong midday sun may have the thermometer soaring up 40 degrees, to drop again to subzero at night.

The building enclosures are mainly of glass.

Economic Analysis

As soon as the preliminary site development plans had been prepared by the architect, the engineers were confronted with the task of selecting the most suitable and economic method of heating the entire project. For this purpose a study was made of the economics of the various available fuels and different heating systems.

Fuels. It was established that coal and gas are readily available, that No. 2 oil can be obtained dependably and that the supply of No. 6 oil is erratic and at unstable price. Heavy oil was, therefore, not considered as a primary fuel for central plant use. No. 2 oil was considered for the individual heat sources of the housing area.

Heating the Housing Areas. The housing areas were considered apart from the other areas. Under Phase 1 of the construction program approximately 1100 detached and semi-detached homes are being constructed.

In view of the arrangement of the houses in each group, one local heat source was assumed for any three homes.

The following four types of heat sources were considered.

(A) HTHW Distribution

An underground piping distribution system from a gas or coal fired central heating plant to distribute HTHW to the heat source for the individual homes. The heat source to be HT-LT hot water heat exchangers.

(B) High Pressure Steam Distribution

An underground steam distribution system from a central gas or coal fired heating plant to supply high pressure steam to the heat source for the individual homes. The heat source would be steam to water heat exchangers.

(C) Individual Oil Fired Boilers

A separate No. 2 oil fired boiler to generate steam or hot water for distribution to the individual houses.

(D) Individual Gas Fired Boilers

A separate gas fired boiler to generate steam or hot water for distribution to the individual houses. An underground gas piping system would be provided to supply gas to each boiler.

The analysis indicated that while HTHW distribution was cheaper than high pressure steam distribution, both with regards to capital investment and annual operating cost, the installation of individual boilers was considerably cheaper with respect to capital investment than both.

Differentiating between oil fired and gas fired individual boilers analysis further indicated that the installation of individual gas fired boilers required a capital investment of $375,000 more than the installation of individual oil fired boilers. However, the annual operating cost of the individual gas fired boilers is approximately $143,000 lower than with oil fired equipment.

Since the annual saving of $143,000 represented a better than 35 per cent return on investment, the engineers recommended the installation of individual gas fired boilers. Hence the housing areas were excluded from further consideration in the design of the district heating scheme. Warm air heating was finally selected by the Architects with individual gas fired warm air furnaces in the individual houses.

Heating the Academic Area, the Service and Air Field Area and the Miscellaneous Buildings

The Academic Area, and the Service and Air Field Area could be supplied with heat by means of HTHW or steam distribution systems, originating from one or more central boiler plants. The miscellaneous buildings, all situated along the major circulating roads, such as Community Center Area, Hospital, Staff Officers' Quarters Area and School could be connected to the HTHW distribution system, or heated from their own individual boiler plants.

For the central boiler plants, coal or gas firing was investigated.

For the individual plants in the miscellaneous buildings, gas was considered as the only fuel so as to avoid the need for excessively long haulage of coal and ashes.

Where gas firing was considered, the cost of installing a gas main from the site boundary to the user was included in the cost estimate.

The following arrangement of type and location of central boiler plants were studied.

(A) One HTHW Plant

HTHW would be distributed to the buildings in the Academic Area, the Service-Air Field Area and to the miscellaneous buildings.

(B) One HP Steam Plant

High pressure steam would be supplied for the Academic Area, the Service-Air Field Area and the miscellaneous buildings.

After studying the distribution system, the engineers came to the conclusion that because of the extreme length of the piping system with its vertical rises and drops due to the character of the site, the method of high pressure steam distribution was not practical. The numerous steam main drip points and pumping stations would make for excessive maintenance costs, consequently the installation of a single HP steam plant was not recommended and not further considered.

(C) Two HTHW Plants

One HTHW plant located in the general vicinity of its principal user, the Academic Area proper, would distribute HTHW to both the Academic Area and the miscellaneous buildings. A second HTHW plant located in the Service Area would distribute HTHW to the buildings within the Service and Air Field Area.

(D) Two HP Steam Plants Individual Plants for Miscellaneous Buildings

One HP steam plant located within the Academic Area would serve steam to the Academic Area. Another HP steam plant located in the Service and Air Field Area would supply steam to the buildings in the Service and

Air Field Area. The miscellaneous buildings would be provided with individual boiler plants.

(E) One HTHW Plant—One HP Steam Plant

One HTHW plant located in the general vicinity of the Academic Area would distribute HTHW to the Academic Area and the miscellaneous buildings. One HP steam plant would supply HP steam to the various buildings in the Service Area.

(F) Individual Boiler Plants for Each Building

One individual boiler plant for each building on the site. It was the engineers' opinion that this method would result in excessive operating and maintenance costs due to the great number of plants required. Consequently, individual boiler plants were not recommended for the Academy.

Costs

Table I, bottom of page 1 drawn up to show the increase in capital investment and annual operating cost of the various schemes over the least costly arrangement summarizes the results of the economic analysis.

The analysis indicated that the installation of one HTHW plant, using gas fuel or two HTHW plants using gas fuel, would produce the same annual operating cost. However, the capital investment required for the two-plant installation was some $700,000 less than that required for the one plant arrangement.

For the two plant arrangement, the annual operating cost for gas fuel was some $40,000 lower than that of coal, while the capital investment required was roughly the same.

Accordingly, two HTHW plants with gas firing were recommended as requiring the lowest capital investment cost, and resulting in the lowest annual operating cost. This was accepted and the design initiated.

Service and Air Field Area System

The central HTHW generating plant and distribution system of the Services and Air Field Area shall receive only brief mention here. The operating principle and general plant disposition are similar to those of the main system.

Two forced circulation boilers are installed having a unit capacity of 30,000,000 Btu/hr when heating up approximately 230,000 lb/hr or 500 gpm from 277 to 406 F. Distribution system circulation capacity when all the buildings are completed and connected will be 900 gpm. The maximum supply temperature is 385 F.

The ground rises toward the air field by approximately 130 ft which causes a loss of static head in the higher sections. The anti-flash margin of 21 deg F between boiler outlet and maximum system supply temperature prevents flashing in case of stoppage of the circulating pumps.

The developed length of the distribution run from the boiler plant to the last user will eventually be approximately $1^1/_2$ miles.

All HTHW piping material is schedule 40, standard black seamless steel pipe. Thermal expansion is taken up by changes in direction and loops. All outside distributing piping is installed underground in insulating presealed steel conduits.

The buildings are heated by unit heaters or by warm air systems and the HTHW is used directly in the coils. There are no process heat requirements and domestic hot water loads are insignificant. Gas fired domestic hot water heaters are therefore provided for the buildings. This permits shutting down the HTHW plant entirely during the summer months.

During the heating season the temperature of the HTHW supplied to the district is modulated inversely with the outdoor temperature between 385 F and 250 F. This simplifies the operation of the individual temperature controllers on the user equipment. It also reduces heat losses in the distribution system.

The central temperature control is carried out by blending return water into the supply to the district and not by changing boiler outlet temperatures and pressures which remain constant at all times.

Main Academic Area System

Atomic Fuel. The use of atomic fuel for heating the Air Force Academy has also been considered.

It was the opinion of representatives of the Atomic Energy Commission that the installation of a nuclear reactor was both practical and technically feasible. However, it was estimated that the installation would take about five years from the time of the appropriation of funds. This was longer than the time allotted for completion of Phase 1 of the construction program.

Nevertheless, it was decided that provision should be made for the eventual future expansion of the Academy facilities. This required siting the plant in such a way as to shield all inhabited areas from the possible effects of radiation.

Geological and meteorological data concerning the site were submitted to the Atomic Energy Commission for study, and their findings were heeded when choosing the site of the plant.

Siting the Central Heating Plant. A secluded narrow side valley was chosen as the location for the Academic Area heating plant. The plant is situated at 7000 ft

TABLE I—COMPARATIVE COSTS

		Capital Investment	Annual Operating Cost
1	Two HTHW plants—gas fired	Cheapest	Cheapest
2	Two HTHW plants—coal fired	$ 10,000 more than No. 1	$ 42,000 more than No. 1
3	One HTHW plant plus one HP steam plant—gas fired	320,000 more than No. 1	61,000 more than No. 1
4	Two HP steam plants, gas fired, plus individual plants in miscellaneous buildings	320,000 more than No. 1	138,000 more than No. 1
5	One HTHW plant plus one HP steam plant—coal fired	380,000 more than No. 1	89,000 more than No. 1
6	Two HP steam plants, coal fired, plus individual plants in miscellaneous buildings	500,000 more than No. 1	305,000 more than No. 1
7	One HTHW plant—coal fired	600,000 more than No. 1	17,000 more than No. 1
8	One HTHW plant—gas fired	690,000 more than No. 1	Same as No. 1

in a fairly central location with respect to the load concentration.

One pair of 14-in. mains goes north to the Academic Area proper. This highest point in this circuit is approximately 250 ft above the boiler house floor. The total developed length of this run from the boiler plant to the farthest user will eventually be approximately $1^3/_4$ miles.

The hospital site is to the south of the boiler plant at a somewhat higher elevation. A pair of 4-in. mains lead to it, and the distance is approximately $^3/_4$ of a mile.

The Community Center is served by a pair of 8-in. mains leaving the plant toward the east, and picking up the various Staff Officers' Quarters Buildings on its way. The developed length to the farthest user in this run is about $3^1/_2$ miles. The low point in this system is situated approximately 250 ft below the level of the boiler house floor.

Designing the HTHW System. The designer's task was to design a HTHW plant and distribution system for the following requirements:

- Capacity—400,000,000 Btu/hr beginning with an initially installed boiler capacity of 300,000,000 Btu/hr.
- Distance of water travel to the farthest user and back—$6^3/_4$ to 7 miles.
- Highest point in system—250 ft above boiler house floor level.
- Lowest point in system—250 ft below boiler house floor level.

The HTHW is strictly a heat carrying medium from the central boiler plant to exchangers in the different buildings. Except for some auxiliaries in the boiler plant, there is no direct use of HTHW in the end users supplied by this system.

In order to produce the most economic design, the following requirements have to be fulfilled:

Temperature spread between supply and return must be high so as to keep the circulation rate and thereby the sizes of the mains to a minimum.

The anti-flash temperature reduction to compensate for the static pressure loss in sections situated above the expansion tank water level must be small and not require that the temperature spread be materially reduced.

The maximum internal pressure in the system composed of boiler pressure, static head and pump head, and which will, therefore, be found at the system low point, must not exceed 770 psig. This is the maximum allowable working pressure in 8-in., Schedule 40, ASTM A 106, Grade B, carbon steel pipe and corresponding welding fittings at the temperatures encountered.

The scheme chosen to meet these requirements is a forced circulation boiler system with common steam-pressurized expansion drum designed for 450 psig operating pressure, and a separate boiler recirculating system. The district is zoned, a high level circulating system supplies 430 F HTHW to the Academic Area and the Hospital situated above the boiler house elevation, and a low level circulating system supplies 450 F HTHW to the Community Center Area, plus miscellaneous buildings, all of which are situated below the boiler house elevation. *Editor's Note: Fig. 3, p. 45 shows the HTHW flow sheet from which this scheme can be visualized.*

Selection of HTHW Temperatures

The normal boiler leaving temperature was selected as 454 F corresponding to a pressure of 440 psia.

At these pressures and temperatures, the saturation temperature pressure curve is such that a small temperature change corresponds to a considerable change in the vapor pressure.

The difference in elevation between the boiler house floor and the highest user is approximately 250 ft and since the water level in the expansion tank is approximately 50 ft above the boiler house floor, the resulting static head loss is 200 ft which in the temperature range under review corresponds to a pressure reduction of 75 psi. In case of a stoppage of the circulation pumps, the effective pressure at the highest point of the system will therefore drop to 365 psia. At this pressure the saturation temperature is approximately 435 F. Hence, at these temperatures and pressures, a 75-psi pressure reduction requires only a 19 deg F reduction in the temperature of the HTHW.

Allowing for a 5 deg F margin, the supply temperature in the distribution system for the Academic Area and the Hospital was designed to be 430 F. Allowing for some temperature drop in the supply line to compensate for losses, the design entering temperature to the users was arbitrarily chosen as 420 F throughout the high level zone. The design temperature drop in the user equipment was selected to be 180 deg F, hence the user leaving temperature is 240 F for space heating and domestic hot water requirements. For the insignificant HTHW supply to the steam generators a temperature drop of 90 deg F was adopted.

The distribution system to the Community Center rises at no point above the expansion tank water level. A temperature reduction is not required, and the HTHW is sent out at 450 F. Admitting a 10 deg F temperature drop to allow for losses in the nearly $3^1/_2$-mile long supply line, the design entering temperature at the users was selected at 440 F. A design temperature drop of 200 deg F is used for the heating and domestic hot water loads, therefore, the user leaving temperature is again 240 F. For the insignificant steam load a 100 deg F temperature drop was allowed with a return temperature of 340 F.

The pressure at the low point of the system is composed of the expansion tank pressure plus the static head gain corresponding to the difference in elevation, plus the pump head. The expansion tank design pressure is 450 psig; the maximum difference in elevation between low point and expansion tank water level is 313 ft corresponding to 112 psi at 450 F. The total pump head is 430 ft corresponding to 153 psi.

The maximum HTHW pressure at the lowest point is therefore, 715 psig, which is 55 psi below the maximum allowable working pressure for pipes and fittings.

The maximum allowable pressure in ASA 300-lb, Class "A" cast steel valves, at 450 F is 650 psig. Hence, inside the central boiler plant and in the Staff Officers' Quarters Area, the use of ASA 300-lb valves is permissible. Only in the lower sections of the system and the Community Center proper are ASA 600-lb valves required. This refers to valves 2 in. and above; for the smaller sizes 600-lb forged steel valves are more economical and therefore, installed throughout.

A study made by the Architect-Engineer responsible for the HTHW installation inside buildings, indicated further that no cost penalty was incurred for using these high temperatures and pressures in user equipment.

Hence, going to the higher pressures and temperatures caused no particular cost penalty. On the other hand, the larger available temperature drop and decreased circulation quantities have resulted in considerable savings in pipe sizes and pump energy cost. These pressures and temperatures selected are, therefore, the optimum for the system.

Design Concept

The principle of generation, circulation and pressurization of the HTHW in the central plant was an important consideration.

Forced circulation boilers were selected. These are once through water heaters without internal recirculation and without drums, depending on pumps to force the water through them.

The expansion and contraction of the water volume of the system is absorbed in the expansion tank in which a pressure cushion is maintained above the water level. This is the basic system pressure which prevents flashing of the HTHW in the system.

The pressure cushion can be created by steam flashing from the HTHW—that is to say, it is generated by the boiler itself in heating up the water. In this case, the expansion tank is located above the boilers. Or the pressure cushion can be an inert gas introduced into the expansion tank under pressure. In the second case, the pressure is independent of the water temperature, and can be made much higher than the HTHW vapor pressure. The expansion tank can be placed where convenient in the boiler house.

Both types of systems were therefore, investigated and the following conclusions drawn:

1. The requirement of a steel structure to support the elevated tank is the only disadvantage of a steam pressurized system.

However, the purpose of the tank is to absorb the change in the volume of the water in the system, hence the criterion affecting the size of the tank is unaffected by the type of pressurization.

2. A gas pressurized system has no safety valves which, in the case of a run-away combustion control, evacuate the excess heat being put into the system. Also flashing will occur if the artificially maintained pressure is lost. Hence, this system does not possess the safety features that are incorporated into steam pressurization.

3. The pressure required for gas pressurization to maintain the same flow temperature of 454 F is higher. In effect, a gas pressurized system would require a pressure of approximately 535 psia in the expansion tank, with corresponding increase in the pressure throughout the system. This is due to the operating range of the temperature controls of combustion being approximately ±10 deg F. In terms of expansion tank pressure, a temperature increase of +10 deg F at 454 F design outlet boiler temperature represents a vapor pressure increase from 440 to 490 psia. If another 10 deg F safety factor is applied then the gas pressure must be maintained at 535 psia, i.e., approximately 524 psig. Allowing for a pressure controller spread of 6 psi and another 5 psi margin, the safety valve setting will be 535 psig. The tank design pressure, therefore, is 85 psi higher than that of the steam pressurized system.

At this tank pressure, 600-lb valves will be required throughout the boiler plant and higher cost pipe and fittings in the low level zone. Hence, the steam pressurized system is cheaper.

The flow principle adopted in the boiler plant is shown schematically in Fig. 3. Three boilers having a capacity of 100,000,000 Btu per hour each, when heating up 517,000 lb/hr, or approximately 1150 gpm, from 272 to 454 F discharge into a common expansion tank supported above them. A separate boiler recirculating system with as many pumps as there are boilers, plus one standby, assures a constant flow through the boilers independent of variations in the flow in the outside districts. These pumps have a capacity of 1150 gpm each, with a 90-ft total dynamic head, and 40 hp motors.

The two groups of district circulating pumps, the high level group and the low level group, each take separate suction from the expansion tank. The returns from both zones are brought together and introduced into the boiler recirculating pump suction line. Thus, the boiler recirculating system receives its water preferentially from the district and takes from the expansion tank only the difference required to make up the full circulating capacity.

The high level zone supplying the Academic Area and the hospital, comprises four pumps of which a maximum of three are in simultaneous service, while the fourth is a standby. These pumps have wound rotor motors which at maximum speed of 3550 rpm, pump 1300 gpm each with a 335-ft total dynamic head; therefore, the total supply rate in the high level zone is 3900 gpm.

The low level zone supplying the Community Center Area plus the Staff Officers' Quarters Area comprises three pumps with a maximum of two in simultaneous service, while the third is a standby. These pumps are equipped with the same type of multi-speed driver. At maximum speed of 3550 rpm, each pump delivers 375 gpm at 430-ft total dynamic head. The maximum supply rate to this zone then, is 750 gpm.

In these systems supply temperatures are maintained constant, and the varying flow rate reflects the heat absorbed in the users. For taking care of the flow variations, the wound rotor motors have six speeds. The speed of all pumps in one group are set simultaneously

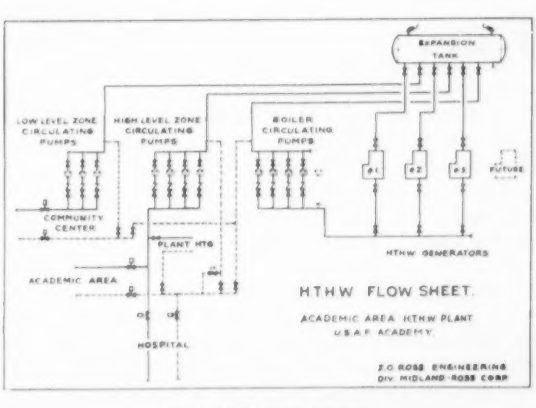


Fig. 3—HTHW flow diagram

by a common speed selector. The multiple pump arrangement allows further flow adjustment by adding or taking off pumps.

A system with separate boiler recirculating pumps in preference to one in which the district circulating pumps take on the additional task of assuring circulation through the boilers was adopted for the following reasons:

1. The combined head required for overcoming system and boiler resistance would otherwise have been excessive.
2. The requirement of maintaining different temperatures in two circuits would have caused considerable complications.

The expansion tank is designed to absorb the volume variations of the returns only between the upper and the lower operating temperature limits. However, in view of the size of the system the normal expansion is approximately 18,000 gal. This expansion volume can be required in the system in a single day when, after the heavy heating load of a cold, clear early morning, with a heavy cooking steam and domestic hot water load added, the intense solar irradiation of the early afternoon materially reduces the heating requirements.

In addition to the 18,000 gal expansion capacity, a 6500 gal water reserve was included in the tank. This would permit the boilers to steam for 5 min at full capacity in case of an emergency.

Incorporating these capacities, the total expansion tank size is 11-ft diam by 60-ft length. Its construction follows the rules of the ASME Unfired Pressure Vessel Code.

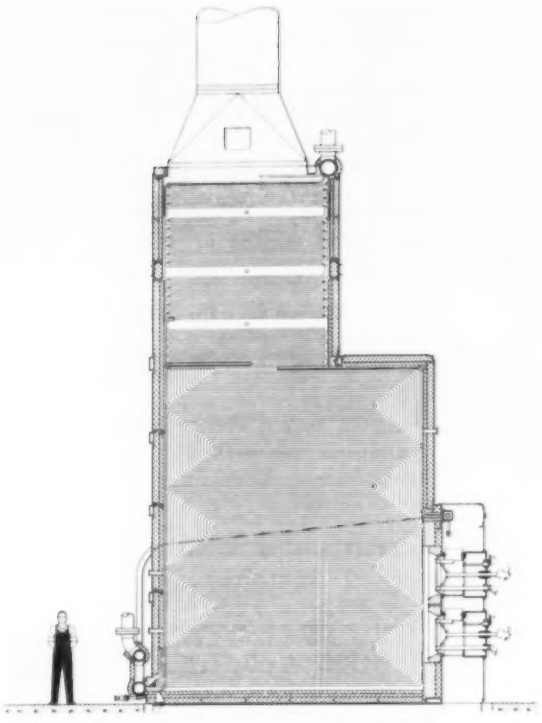


Fig. 4—Combustion engineering LaMont HTHW controlled circulation boiler

Plant Design

Once the basis of design had been selected, separate boiler specifications were prepared and sent out for bids. The boilers were advance procured and the plant designed around the boiler purchased.

The contract for the boilers was awarded to Combustion Engineering, Inc., for their Controlled Circulation LaMont boilers. This type of HTHW generator occupies little floor space, but is somewhat tall. Fig. 4 shows a side elevation. All water enters the boiler at the header located at the rear and near the firing floor. Water passes from this header to and through the tubes in rear wall, side walls, front wall and roof, and up through the convection section where it is collected in the outlet header. The inlet to each tube circuit is equipped with and orifice to control circulation through each tube in accordance with its capacity to absorb heat.

Gas flow is straight up and encounters no baffles. The stack is supported by the boiler itself. The casing is gastight, and the boiler is made for pressurized firing employing a forced draft fan only.

The boiler house disposition is that of a rectangle. On one side of the generous firing aisle are the boilers as well as the graphic panel board and most of the auxiliary equipment. On the other side of the firing aisle in a row are the circulating pumps. The expansion tank is overhead, above the center aisle with its underside approximately 14 ft above the boiler outlet. The office is on the mezzanine. Underneath the operating floor a pipe basement houses all the piping and practically all the valves. Valves are operated from the operating floor by floor stands. This disposition makes for a neat piping arrangement and allows for high flexibility, an important consideration when dealing with 18-in. piping and 450 F temperature. A panel board serves the operation of the plant. It consists of a graphic panel front on which the system is portrayed diagrammatically, with the various plant indicators, combustion controllers and alarms mounted thereon, and a recorder panel at the rear of the main board on which all of the plant recorders are mounted. The combustion control system is of the metering type, with either manual or automatic operation from the board.

The valves in this system are operated manually with the exception of motorized valves installed in each outgoing and return line to the district where these come into the boiler house. These motorized valves are operated by remote control from the control panel and serve the purpose of sectioning the district in the event of a major pipe break there. In such a contingency the operator will have his hands free to tend his boilers without having the additional task of closing, for example, two 14-in. valves.

A separate speed selector board serves to operate and select the speed of the circulating pumps.

Gas is the normal fuel, with No. 6 fuel oil serving as a standby. The boilers are equipped with ring type gas burners and wide range mechanical atomizing oil burners. The fuel oil makeup system was so designed that the fuel oil is available at full capacity after a minimum of two hours' notice prior to interruption of gas service. The oil storage tanks contain a two days' supply at full boiler capacity.

The boiler efficiency is guaranteed to be 76 per cent

when firing gas. Air preheaters were considered, but it was found that since the boilers are operated at partial load most of the time, the obtainable increase in efficiency did not provide a satisfactory return on the investment, and therefore, air preheaters were not installed.

All burner and fan equipment capacities and performances were specified for an altitude of 7000 ft above sea level, where the density of the air is considerably less, atmospheric pressure being only 11.3 psia.

The feedwater makeup system is conventional, comprising a Zeolite softener and thermal deaerator storage tank. However, in view of the negligible makeup requirements of the closed HTHW System its size is very small. As a result we are not giving the design details of this equipment.

A small MTHW System with an HTHW to MTHW heat exchanger serves fuel oil and plant heat requirements.

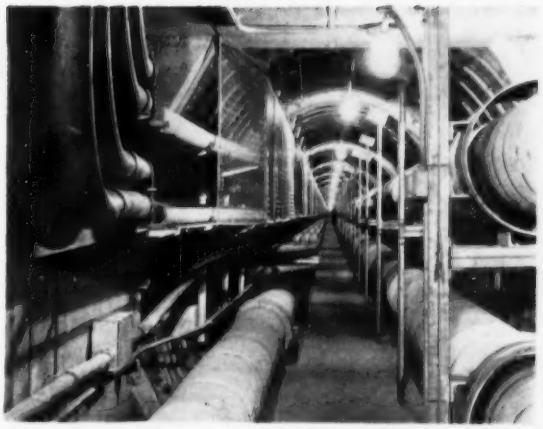


Fig. 5—View of utility tunnel—14-in. HTHW mains are at right; potable water, electrical and communications services at left

HTHW Piping

All HTHW piping in and outside the boiler plant is ASTM A-106B, seamless black carbon steel, Schedule 40. The pipes are joined by welding, and welding fittings are used throughout. All pipe 2 in. and larger are butt welded, piping $1^1/_2$ in. and smaller is socket welded. Backing rings are used for pipe $2^1/_2$ in. and up and socket welding couplings for straight sections of pipe $1^1/_2$ in. and under.

All valves for HTHW service 2 in. and larger, inside the boiler plant are flanged and in the outside distribution system they are welded in the line. All smaller valves are welded in the line.

All thermal pipe expansion is taken up by change of direction or by expansion loops. Expansion joints are not employed, not even in the tunnels where it was preferred to excavate loop chambers to house the loops.

The mains to the Academic Area are installed in a walking tunnel, Fig. 5, which carries also other services, such as potable water, electric power and telephone. For the first 810 ft of its run, the tunnel is bored through a ridge separating the boiler plant from one of the main valleys, and the tunnel is plate lined. During this portion the tunnel drops to its lowest point, some 40 ft below the boiler house floor. From there on, the tunnel is located in a trench dug from the surface, and constructed of concrete. It rises steeply to the Academic Area.

Since this is a long tunnel carrying other services besides HTHW, it had to be made suitable for human occupancy by maintenance personnel. Calculations were made which showed that in winter the tunnel temperature without ventilation would be 133 F and in summer 157 F. A mechanical ventilation system was therefore installed, designed to limit the average tunnel temperature to a maximum of 110 F when the outside air temperature is 95 F and to provide an ample air supply which can be doubled in any portion that is occupied for prolonged periods.

The arrangement of the tunnel ventilation consists of sealing off the tunnel and providing a two-speed centrifugal exhaust fan of 20,000–10,000 cfm with exhaust shaft to grade in the first loop chamber near the heating plant and, a similar installation with 16,000–8000 cfm capacity in the last loop chamber at the Academic Area end. In between these two high points of the system air intake shafts from grade are provided in the loop chambers except in those in the bored section. All shafts, whether for intake or for exhaust, are provided with penthouse louvers in the side walls, and a ladder and a hinged top so that they serve also as a means of emergency egress from the tunnel. Thermostats are installed for automatic operation of the two exhaust fans when there is no occupancy. Fig. 5 illustrates the arrangement of service lines in the tunnel.

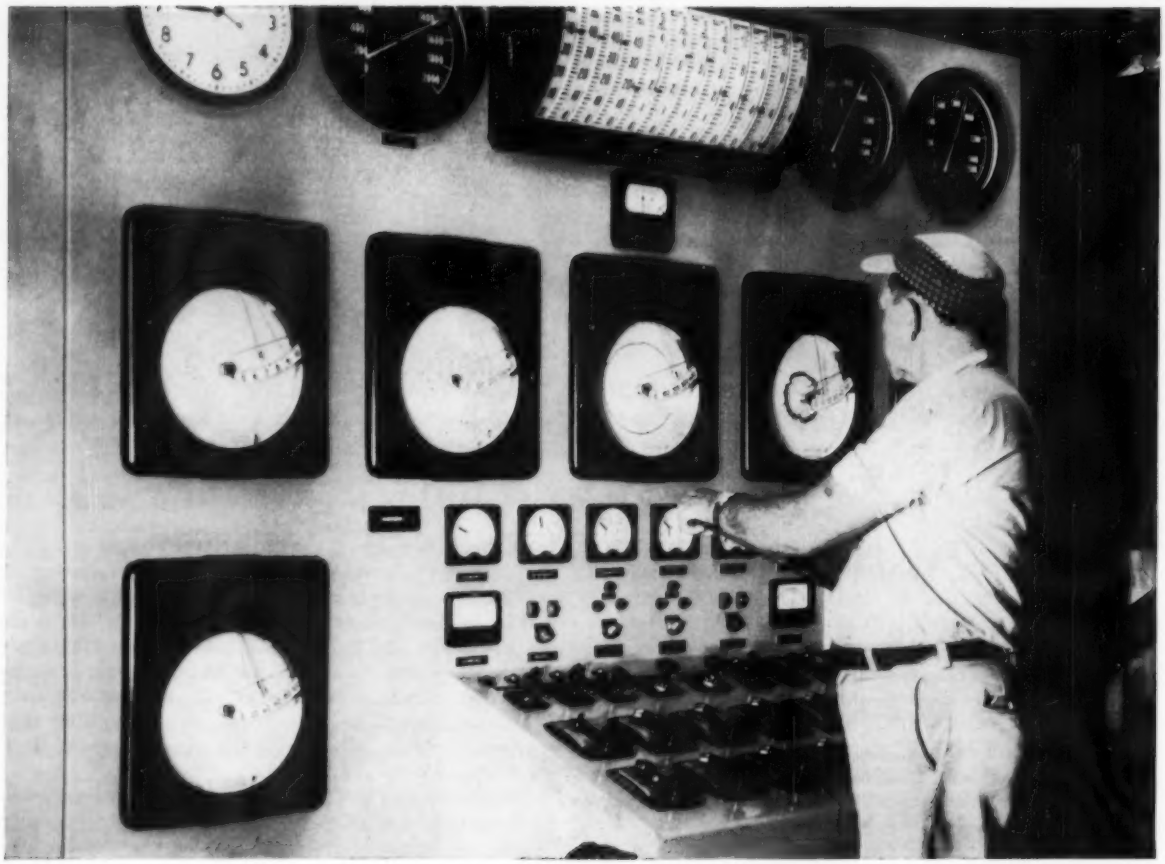
The mains to the Community Center are completely underground and those to the Hospital partly underground and partly above ground on concrete piers. Both are installed in insulated presealed conduits of the spirally corrugated or spirally welded flat sheet steel type.

After joining the conduit section and before applying anti-corrosion coating to the joints, a 15 psig air test was made, and the joints proved tight with a soapsuds solution.

These runs cross a number of ridges and valleys and in between the ground is by no means even. Although a HTHW system requires no continuously operating traps such as a steam distribution system does, it needs, all the same, vents at the high points and drains at the low points which are used when filling or draining the system.

For reasons of economy, it is desirable to keep the number of such points to a minimum and the runs were profiled with this end in mind. Thus, the run to the Community Center starts at the plant at an elevation of 7008 ft, drops to 6949 ft, rises again to 7022 ft, drops to the system low point at 6757 ft. From there it rises again to 6959 ft and drops toward the Community Center Area where the low point is 6860 ft. Thus, for the entire length of $3^1/_2$ miles only two drain and two vent manholes are required. Similar conditions exist in the run to the Hospital.

The HTHW district heating system terminates with heat exchangers in the buildings it serves. The heat is transformed for use in LTHW and warm air heating systems, air conditioning with absorption type refrigeration, domestic hot water storage heaters, and steam generators for process steam supply to the kitchens and laboratories.



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By IGOR J. KARASSIK*
Worthington Corp.

The boiler feed pump and its associated equipment represent a major operating and maintenance consideration in today's power plant. Here we run in question and answer form a series of clinic sessions on various boiler feed pump problems. The replies are the work of one of the topmost pump authorities and give specific information which we hope will prove valuable to our readers.

Steam Power Plant Clinic—Part XI

QUESTION

I have been studying low cost, economical packaged steam power plants in the range of 15,000 to 20,000 kw intended for use as peak-shaving plants or at the end of lines as an additional source of power. Among various problems, I have been analyzing the most economical means of transferring condensate from the condenser hotwell, operating at approximately 26-in. Hg vacuum, to a steam generating unit operating at approximately 400 psig.

After studying a number of different possibilities, I came to the conclusion that a vertical can type pump, Fig. 1, combining the functions of the condensate and boiler feed pumps into one unit offers several advantages. This solution should certainly result in a lower initial equipment cost and should reduce the installation cost. For the particular size plant I am projecting, the vertical can pump should be designed to handle approximately 300 gpm against a discharge pressure of 500 psig. No heaters would be used between the condenser and the boiler.

I would appreciate any comments you would care to make on the merits of this solution.

ANSWER

I will readily admit the merits of any solution which will reduce the initial equipment cost of a unit intended strictly for peak or end-of-line service, even if the savings are achieved at the expense of slightly increased operating costs. In this particular case, however, there are a number of considerations which tend to make the solution less desirable than it appears at first glance.

By definition, condensate pumps should operate at low speeds in order to maintain the lowest possible required NPSH. Likewise, by definition, boiler feed pumps should operate at the highest possible speeds for the high pressures that they have to develop. Higher speeds result in compact units, less costly and more reliable than low speed pumps. The best speed for a condensate pump in the range of capacities you mention would be 1750 rpm. On the other hand, 1750 rpm is a very poor speed to develop the 1190 feet total head required here, and the boiler feed pump should operate at 3500 rpm. As a result, the idea of combining these two functions into a single pump may appear to be desirable from the point of view of first cost, but once you get into the problems of incompatibility between the two services, much of this attraction disappears.

This does not mean that such a pump could not be developed and built. It would be highly impractical to design it for operation at 1750 rpm, as this might require from 16 to 20 stages. At 3500 rpm, a seven-stage pump with $7^1/_4$-in. impellers could be built for 300 gpm and 1190 feet total head. A rather special design would be required, with heavier walls for the individual stage bowls, heavier bolting throughout and with special bearings. Vertical can type condensate pumps are generally built so that the motor carries the axial thrust. In this case, it would be necessary to provide a thrust bearing in the pump itself.

One very important factor to consider is that the vertical can type pump has water-lubricated bearings. These will naturally not have the long life normally associated with horizontal shaft pumps fitted with oil or grease lubricated bearings. Therefore, a shorter life might be expected for this combined pump before clearances must be restored than would be the case with a separate horizontal boiler feed pump.

I do not intend to comment in detail on the question of the elimination of all heaters. This obviously reduces the cost of the unit and the effect on its performance is apparently not a factor in your estimation. I assume that you have discussed the effect of supplying the boiler with feedwater at condenser hotwell temperature

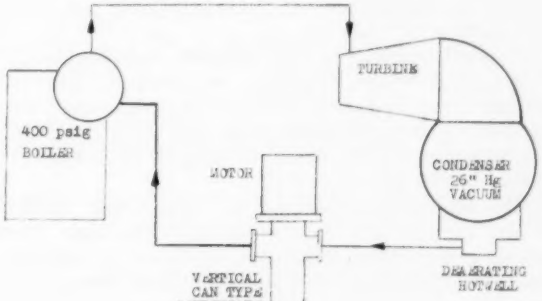


Fig. 1—Proposed simplified feed water system employing a vertical can type condensate and boiler feed pump

* Consulting Engineer and Manager of Planning, Harrison Div.

with the boiler manufacturers for their suggestions.

On the other hand, there will be no doubt cases where closed heaters fed with extraction steam will be required by the ultimate customer. In that event, the effect of combining the two functions into a single pump will be unfavorable. If the heaters are located between the condensate and boiler feed pumps, they need be good for at most 100 psig. If the heater or heaters are located after the combined condensate-boiler-feed pump, they must be good for the maximum pressure developed at shut-off which will be of the order of 600 psig. This will increase the cost of the heaters and much of the savings contemplated will have been dissipated.

In short, it would seem to me that the more conventional arrangement with a separate condensate pump, a deaerating heater and a boiler feed pump is a more desirable arrangement. Note that the cost of the feedwater pumping equipment represents only a few per cent of the total unit cost. The savings obtainable from the scheme you have described would be of almost negligible proportion in relation to the total plant cost. We have made no comments on corrosion effects.

Editor's Note: Since the inception of this series a number of inquiries have been made on the individual Clinic problems discussed by Mr. Karassik. Recently readers have asked if they can present problems of their own to Mr. Karassik for his comments. These, the author assures us, are most welcome. He will answer readers directly and we shall publish these answers as quickly as our schedule permits.

QUESTION

In my previous question, regarding our study of the power plant addition, I mentioned a design vacuum of 26-in. Hg. However, we have not yet decided on the final design condition and I would like your comments on the method of selecting a reasonable back pressure for which we should design the condenser installation.

ANSWER

There are a number of separate factors which must be taker. into consideration before one can determine the design vacuum for a condenser. The first of these will be the performance of the turbine at varying back pressures. This is information which you can obtain from the turbine manufacturer. The turbine water rate varies as a function of the back pressure: the higher the absolute back pressure, the higher the steam input for the same turbogenerator output. Contrarily, the lower the back pressure, the lower the steam input—but the larger the condenser for a given temperature of the cooling water. The net result is that at some point, a further improvement in vacuum cannot justify the increase in condenser size.

A complete evaluation is necessary to determine the best overall design condition, but generally speaking, the minimum difference between the inlet steam temperature to the condenser and the inlet circulating water temperature (called Initial Temperature Difference) should be at least 20 deg. F.

The following table lists the relationship between design vacuum and cooling water temperatures which are considered good practice. These can be used as a guide for determining an economical design vacuum.

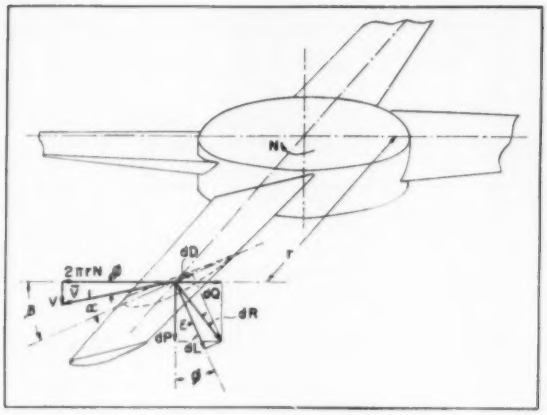
Cooling Water Temperature in °F	Recommended Minimum Absolute Pressure (In. Hg)
60	1.0
70	1.5
80	2.0
85	2.5
90	3.0
95	3.5

If a condenser is designed for a lower absolute pressure than indicated in this table for its respective cooling water temperature, it will be necessary to use an abnormally oversized condenser, excessive cooling water quantities, or both.

Keeping these relationships in mind, the next question concerns the value of the water temperature to be used as the "design condition," if there is considerable variation in this temperature over the year. Generally speaking, it is not logical to select the maximum temperature which may prevail for possibly only a few days in the hot summer months, since this would result in a greatly oversized condenser. Nor should the coldest temperature reached during the winter months be used since a condenser sized on this basis would be much too small for the warmer periods. Therefore, some mean temperature should be used, such that the higher steam flow to the turbine required when the back pressure increases with warmer cooling water temperatures is more than offset by the savings in steam resulting from the lower pressures when the water is colder than at the design conditions.

Thus, the temperature selected for design may be anywhere from 5 deg. to 15 deg. F lower than the warmest temperature reached during the year. The exact value will depend upon local conditions and the conservatism of design, but always with full consideration to the economical initial temperature relationships outlined above.

In the larger installations, a very complete evaluation is usually made, based on historical data with regards to the prevailing water temperatures over the twelve-month period. The aim of this evaluation for selecting the design temperature is to have the coal pile diminish as slowly as possible over the entire year, without at the same time investing uneconomically in the initial cost of condenser and auxiliaries.



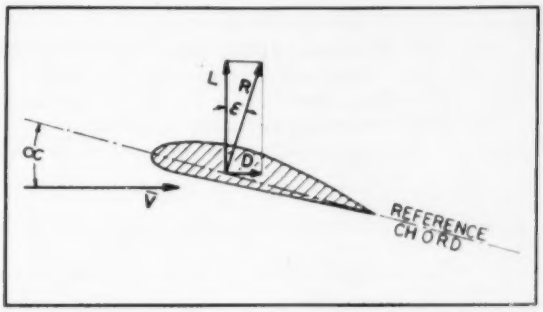


Fig. 2—Forces acting on a wing can be resolved as above

Fig. 1—Analysis points for a fan blade as an airfoil

Cooling Tower Fan Performance*

By GEORGE W. FORMAN† and NEIL W. KELLY‡

Univ. of Kansas J. F. Pritchard and Co. of California

THE mechanical draft cooling tower has become an important equipment component in chemical plants, petroleum refineries, electric power plants, and large air-conditioning installations. Lack of natural water in adequate quantities for cooling purposes often dictates the use of evaporative water cooling in order that available water may be recirculated within the plant. Numerous publications have dealt with the thermal performance of cooling towers, but little has been presented concerning the performance of the large axial-flow fans which have come into common cooling tower use. Misconceptions exist concerning the effects of differences in fan diameter, number of blades, blade shape, fan rpm, the design of air discharge cylinders, stacks, and so forth. This paper is presented to clarify some of these misconceptions and to show a method of predicting the performance of cooling tower fans which requires a minimum of dimensional and descriptive data.

Performance Requirements

The performance requirement of a given cooling tower fan application depends upon the thermal duty of the cooling tower served. The volume of air required may range from a few thousand to nearly a million cubic feet per minute, and the static pressure against which the fan must operate will ordinarily be less than $^3/_4$-in. water gage. The fan operates in a horizontal plane at the top of the cooling tower in a warm, moisture-saturated air stream. The cooling tower designer's problem is to select from a fan series the fan diameter, number of blades, and rpm which require the minimum horsepower consistent with available space, available reduction gearing, and first cost of the overall cooling tower installation.

Fundamental Considerations

Theoretical analysis of the performance of a fan does not yield precise information, and tests are necessary in order to obtain exact performance data. However, considerable insight may be gained through a simple and straight forward analysis by considering the fan blade as an airfoil. The forces acting on the blades (and hence the forces exerted by the blades on the air stream) may be estimated by considering an element of the blade as shown in Fig. 1.

An element of blade of length dr at radius r will operate essentially as does a section of an airplane wing in flight.

Referring to Fig. 2, the forces acting on a wing may be calculated from

$$L' = \rho/2 \times \bar{V}^2 C_L A \quad (1)$$

$$D = \rho/2 \times \bar{V}^2 C_D A \quad (2)$$

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‡ Manager of Manufacturing.
* Contributed by the Power Division for presentation at the Semi-Annual Meeting, St. Louis, Mo., June 14–18, 1959, of the ASME as Paper No. 59-SA-17.

NOMENCLATURE

L = lift force on an airfoil acting perpendicular to direction of relative wind, lb
D = drag force on an airfoil acting parallel to direction of relative wind, lb
ρ = mass density of air, lb sec²/ft⁴
V = axial air velocity, ft/sec
$\bar{V}$ = velocity of relative wind, ft/sec
C_L = airfoil lift coefficient, dimensionless
C_D = airfoil drag coefficient, dimensionless
A = area, sq ft
α = airfoil angle of attack, deg
r = radius, ft
R = resultant force on airfoil, lb
Q = component of force in the plane of fan rotation, lb
P = component of force perpendicular to plane of fan rotation, lb
N = fan speed, revolutions/sec
ϕ = angle between direction of relative wind and plane of fan rotation, deg
ϵ = angle whose tangent is D/L
η = fan efficiency
p_t = total pressure rise, lb/sq ft
p_v = velocity pressure, lb/sq ft
S = fan solidity, the decimal fraction of fan circumference at radius r, occupied by blades
W = total blade width at radius r, ft

where

L = lift force, acting perpendicular to the direction of relative wind, pounds

D = drag force, acting parallel to the direction of relative wind, pounds

ρ = mass density of the air, pounds × sec²/ft⁴

A = wing plan area, ft²

C_L and C_D = coefficients depending upon the angle of attack α and the airfoil shape

α = angle of approach of wind relative to the airfoil

V = velocity of relative wind, ft/sec

The efficiency of the blade element at radius r will be determined in the following analysis. Referring again to Fig. 1, the lift and drag forces for the blade element may be calculated, and the resultant air force dR on the element found as the vector sum of the lift and drag forces. By resolving the resultant force into components parallel to the axis of rotation of the fan and in the plane of the fan, the useful output or working force dP and the torque component dQ may be determined. From these, the efficiency may be found. From Fig. 1

$$\tan \phi = V/2\pi rN, \tag{3}$$

where N = speed, revolutions per second.

Also, from Fig. 2

$$\tan \epsilon = D/L = \frac{\rho V^2 C_D A/2}{\rho V^2 C_L A/2} = C_D/C_L$$

The useful power output is the product of the force component parallel to the shaft axis and the velocity of the air

$$\text{Output} = V dP \tag{5}$$

The power input is the product of the torque component dQ and the velocity at which it moves

$$\text{Input} = 2\pi rN dQ \tag{6}$$

The efficiency of the blade element will be

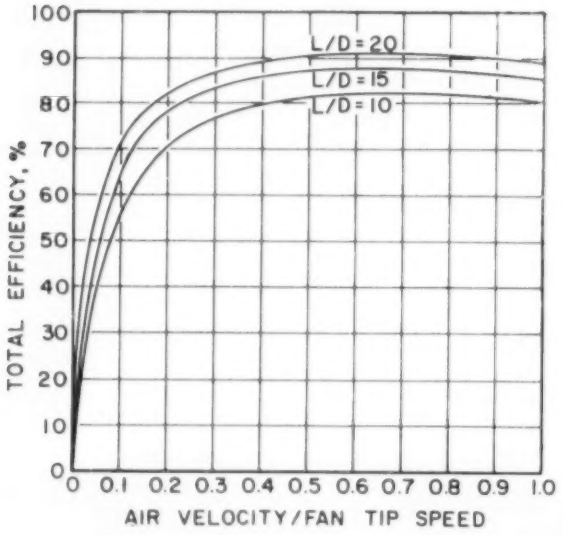


Fig. 3—Total fan efficiency versus air velocity to tip speed ratio

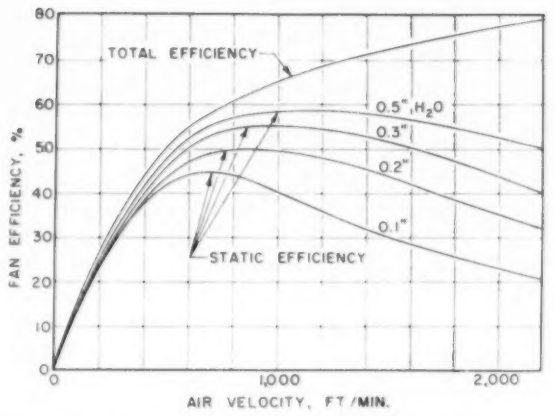


Fig. 4—Total and static efficiency at constant tip speed of 10,000 fpm and an airfoil lift/drag ratio of 15

$$\text{Efficiency} = \eta = \frac{\text{Output}}{\text{Input}} = \frac{V dP}{2\pi rN dQ} = \frac{dP}{dQ} \tan \phi \tag{7}$$

From Fig. 1,

$$dP = dR \cos (\phi + \epsilon) \tag{8}$$

$$dQ = dR \sin (\phi + \epsilon) \tag{9}$$

Thus by substitution

$$\eta = \frac{dR \cos (\phi + \epsilon)}{dR \sin (\phi + \epsilon)} \tan \phi = \frac{\tan \phi}{\tan (\phi + \epsilon)} \tag{10}$$

In this expression for efficiency, the angle ϵ depends on the airfoil lift and drag: If the airfoil is "good" ϵ will be small. The angle ϕ depends on the ratio of the air velocity through the fan to the tangential velocity of the blade element. Since both ϵ and ϕ usually vary from hub to tip of the fan blade, an integration is necessary to obtain the overall efficiency of the fan accurately.

Fortunately, the efficiency of the fan as determined by an integration from blade root to tip is approximated by the efficiency of the blade element three quarters of the distance from the center of rotation to the blade tip, i.e., at 75 per cent radius. Fig. 3 shows a plot of fan total efficiency calculated from Equation (10) and relates efficiency to the ratio of air velocity through the fan to fan tip speed, which is proportional to tan ϕ. The family of curves represents airfoils of different lift/drag ratio.

It is apparent from Fig. 3 that total efficiencies in the order of ninety per cent are possible, provided the airfoil lift/drag ratio is about 20:1 and the helix angle ϕ (as indicated by the ratio air velocity through the fan divided by fan tip speed) is within certain limits. Total efficiency, however, is not a criterion of the relative power required by different fans in handling the same air flow against the same static head. A more meaningful indication is given by "static efficiency," defined by

$$\eta_{st} = \text{static efficiency} = \eta_{tot} \times \frac{\text{static pressure}}{\text{static pressure} + \text{velocity pressure}} \tag{11}$$

Note that the static efficiency of the fan is always less than its total efficiency, but that the static efficiency approaches the total efficiency as the discharge velocity

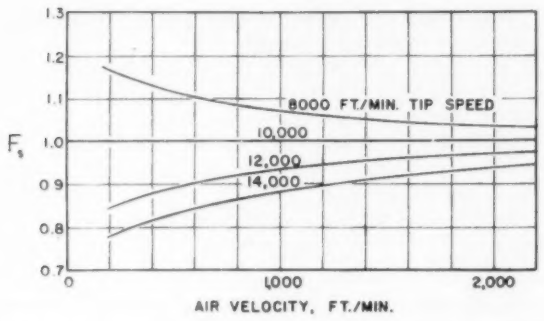


Fig. 5—Correction factor for Fig. 4 for tip speed other than 10,000 fpm

approaches zero. Thus the fan is charged with the discarded kinetic energy, and the fan with the highest static efficiency will require the minimum input horsepower to deliver a given air volume against a given static pressure.

Fig. 4 shows the relationship between efficiency and air velocity through the fan for various static pressures. This plot is based on a constant fan tip speed of 10,000 feet per minute and an airfoil lift/drag of 15. Current practice is herein exemplified: Common tip speed values range from 8000 to 13,000 ft per minute, and an L/D of 15 represents a "good" airfoil application.

For fans operating at tip speeds other than 10,000 fpm, a correction factor has been calculated (Fig. 5) to be applied to the efficiency indicated by Fig. 4. Similarly, a correction for an airfoil lift/drag ratio other than 15:1 must be applied. The airfoil correction factor is shown in Fig. 6. The corrected efficiency may be found from

Corrected efficiency =

$$\text{Efficiency, Fig. 4} \times F_s \times F_a \quad (12)$$

A brief study of the information thus far presented indicates that fan static efficiencies of about 50 to 60 per cent are possible for fans operating against static heads of approximately 0.5 in. of water. Higher efficiencies would require lower than common tip speeds, or airfoils that are considerably better than the ones in use today.

Figs. 4, 5, and 6 can be used for predicting the horsepower required for any cooling tower fan application if the operating L/D of the fan is known or can be determined.

Number of Blades and Blade Width

The lift/drag (L/D) ratio at which the airfoil operates depends on the physical shape of the airfoil and the angle of attack. Many systematic wind-tunnel studies of airfoil contours have been conducted, and the findings are readily available in reports of The National Advisory Committee for Aeronautics. Fig. 7 shows a plot of the lift coefficient C_L and the lift/drag ratio as functions of the angle of attack for a Clark Y airfoil. This particular airfoil has found wide use in axial flow fans and aircraft propellers and can be taken as typical of a good airfoil.

By taking the characteristics of the Clark Y airfoil as typical of common cooling tower fan designs, the value of L/D can be determined for given operating conditions for a given fan "solidity." The procedure is as follows:

Referring to Fig. 1, the force dP is equal to the total air load on the element of fan disk area at radius r, i.e., is equal to the total pressure differential across the fan disk times the area of the element dr. In equation form

$$dP = p_t 2\pi r\, dr \quad (13)$$

where p_t is the total pressure rise, pounds/foot.[2] Also,

$$dP = dR \cos(\phi + \epsilon) \quad (14)$$

Combining Equations (13) and (14)

$$dR = p_t 2\pi r dr/\cos(\phi + \epsilon) \quad (15)$$

But

$$dR = dL/\cos\epsilon = C_L W dr \rho \bar{V}^2/2 \cos\epsilon \quad (16)$$

where W = the total blade width in feet at radius r, i.e., the product of the number of blades and the width of each blade.

Setting the two expressions for dR equal to each other

$$C_L W dr \rho \bar{V}^2/2 \cos\epsilon = 2\pi r dr p_t/\cos(\phi + \epsilon) \quad (17)$$

or

$$p_t 2/\rho \bar{V}^2 = C_L W \cos(\phi + \epsilon)/2\pi r \cos\epsilon \quad (18)$$

Let $W/2\pi r = S$ = solidity, i.e., the decimal fraction of the fan circumference at radius r occupied by blades, then

$$p_t 2/\rho \bar{V}^2 = C_L S \cos(\phi + \epsilon)/\cos\epsilon \quad (19)$$

From Fig. 1, $\bar{V} = V/\sin\phi$ (20)

Substituting

$$p_t 2/\rho V^2 = C_L S \cos(\phi + \epsilon)/\cos\epsilon \sin^2\phi \quad (21)$$

since $\rho V^2/2 = p_v$, we can write

$$p_t/p_v S = C_L \cos(\phi + \epsilon)/\cos\epsilon \sin^2\phi \quad (22)$$

In Equation (22), C_L and ϵ are associated with the performance of the airfoil. This equation may be used to determine the L/D at which a given fan must operate to produce a particular volume of flow against a *known static head*. (Performance at the $^3/_4$ radius is taken as the "average" performance of the entire blade.) Fig. 8 shows a plot of Equation (22) based on the Clark Y airfoil. Fig. 9 presents a graph from which the value of p_t/p_v can be easily read for known values of air velocity

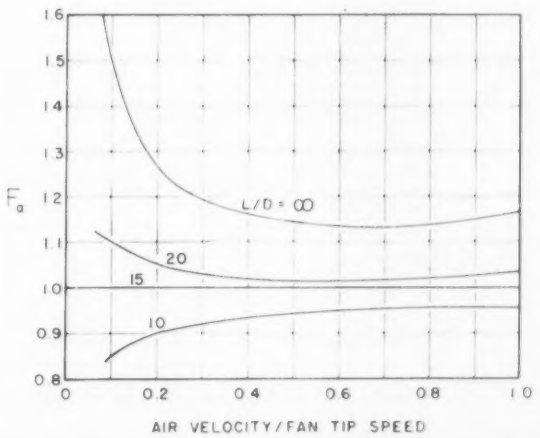


Fig. 6—Correction factor for Fig. 4 for airfoil lift/drag ratio other than 15

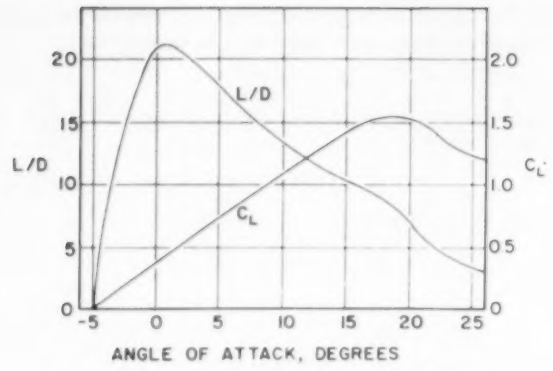


Fig. 7—Airfoil characteristics for Clark Y Airfoil

and static pressure. It is apparent from the last derived equation that a required fan solidity may be provided by either a few wide blades or several narrow blades. The method of fabrication of the blades controls the design choice of number of blades: The economics of cast blades calls for a relatively large number of narrow blades; with fabricated construction fewer and wider blades are used.

By using Fig. 8 in conjunction with Figs. 4, 5, and 6, the horsepower required for any fan can be predicted if the following information is known:

(1) Air volume, cfm
(2) Static pressure
(3) Fan diameter
(4) Fan rpm
(5) Number of blades
(6) Blade width at $^3/_4$ radius

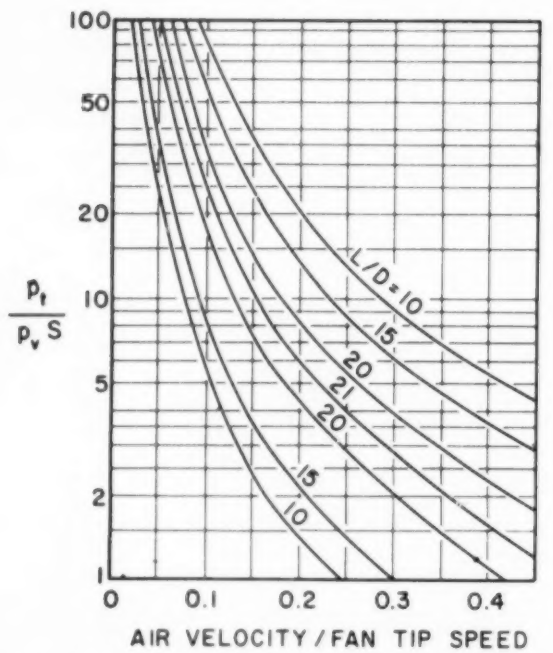


Fig. 8—Chart for determining airfoil lift/drag ratio required for given performance requirement

To illustrate the method of performance calculation consider the following example:

A six-bladed, 19-ft diameter fan with a 63-in. diameter hub is to handle 372,000 cfm against a static pressure of 0.400 in. water (actual values), and the air has a density of 0.0705 lb/ft³. The blades are $18^3/_{16}$ in. wide at the $^3/_4$ radius, and the fan is to operate at 175 rpm. What horsepower is required? (Note: This set of numbers has been chosen for illustration, since under these conditions a field test gave a motor output of 50.8 BHP.)

Solution:

Fan tip speed = $\pi \times 19 \times 175 = 10{,}450$ ft/min
Air velocity through fan = $372{,}000 \times 4/\pi \times [19^2 - (63/12)^2] = 1420$ ft/min
Air velocity/tip speed = $1420/10{,}450 = 0.136$

The static pressure that would exist in "standard air" would be

Standard static pressure = $0.400 \times 0.075/0.0705 = 0.425$ in. H_2O

From Fig. 4, the uncorrected static efficiency = 0.56
From Fig. 5, the tip speed correction factor = $F_s = 0.995$

To find the airfoil correction factor F_a from Fig. 6, we must first find the L/D at which the airfoil will operate. Assume the fan to have a Clark Y airfoil. (The actual characteristics will not be greatly different from the Clark Y for a fan of reasonable design.)

$$\text{Solidity} = S = \frac{6 \times 18.19/12}{\pi \times 19 \times {}^3/_4} = 0.203$$

From Fig. 9, for $V = 1420$ and $p_s = 0.425$, $p_t/p_v = 4.40$
Thus, $p_t/p_v S = 4.40/0.203 = 21.7$
From Fig. 8, $L/D = 19$
From Fig. 6, $F_a = 1.05$
The static efficiency = $0.56 \times 0.995 \times 1.05 = 0.585$
BHP = air horsepower/static efficiency

$$\text{Air horsepower (static)} = \frac{\text{cfm} \times \text{static pressure, lb/ft}^2}{33{,}000}$$

$$\text{Air horsepower} = \frac{372{,}000 \times 0.400 \times 62.5/12}{33{,}000} = 23.5$$

Horsepower required at the fan shaft = $23.5/0.585 = 40.2$

If the drive mechanism has a 90 per cent overall efficiency, the motor horsepower required = $40.2/0.90 = 44.7$, which is within 12 per cent of the 50.8 experimental value.

In this example, the agreement of the calculated value of the power required and the experimental value is not as precise as desired, but about as good as normally obtained. Considering the difficulties inherent in field measurements, it is believed that the method of calculation here presented is of considerable practical value.

Fan Performance by Tests

No entirely satisfactory instrument has been developed for use in measuring velocities in the air stream of cooling tower fans. Conventional vane anemometers have been used, but the accuracy of calibration as used in the warm, humid air stream that contains water droplets has not been established. The pitot tube is perhaps the most reliable instrument, but accurate measurements here would require the use of a precision manometer which is

not well suited to field test conditions. The air flow on the discharge side (which is the only conveniently accessible location) is not strictly parallel to the fan axis, and correction must be made for the rotational velocity of the discharge air stream. In general, a volume measurement in full scale testing is subject to an error in the order of plus or minus ten per cent. The power input to the fan is impossible to determine, and is generally taken as the power input to the motor driver less assumed values for motor and transmission efficiencies. Tests under field conditions are often influenced by prevailing winds, and a complete range of static pressures cannot be conveniently established. The static pressure is determined by measurements taken in the plenum chamber below the fan, and as such does not include the friction loss due to flow entering and leaving the fan cylinder. (The method of calculation presented in this paper is based on a static pressure difference across the fan disk, and as such must include all static pressure losses throughout the entire system, including the fan cylinder. This difference in static pressures probably accounts for part of the discrepancy between calculated and measured horsepower in the example.)

Fan manufacturers' performance data are usually obtained either through accurately conducted tests of scale models, by theoretical calculation, or through the use of limited full-scale field testing. Well-made models under laboratory conditions provide accurate data which are finding increased use among fan producers, although the basis of published ratings is often vague.

Test data (or other basis of rating) may be presented in many ways, one of which is shown in Fig. 10. Note that this plot is for a specific fan as tested in a fan throat of a particular configuration, and for a tip speed of 10,000 feet per minute. The static pressure drop due to air flow through the fan cylinder is here charged against the fan, and as such the fan and its cylinder are rated as a unit. Fig. 10 was obtained from a 36-in. diameter model of the 19-ft fan discussed in the example and indicates that 58 horsepower is required to handle 372,000 cfm at 0.425 in. water standard static pressure. Thus the power required at an actual air density of 0.0705 lb/cu ft,

$$HP = 58 \times 0.0705/0.075 = 54.5$$

and if the power transmission efficiency is 90 per cent, the motor horsepower required is $54.5/0.90 = 60.5$. Agreement with the full scale field test value of 50.8 is not entirely satisfactory. As in this example, the efficiency of models is usually somewhat lower than full scale fans, due to the difficulty of maintaining tip clearances that are accurately to scale, and the fact that the model operates at a lower Reynolds number.

Fan Cylinders and Stacks

As previously mentioned, the theoretical method of performance estimation set forth in this paper is based on the static pressure difference across the fan disk. In using the method of calculation, it is necessary to estimate the static pressure loss in the fan cylinder in order to obtain best accuracy. The fan cylinder static pressure loss may be taken as some percentage of the velocity pressure at the fan disk. The factor may be as low as 2 per cent, if the cylinder is of well-designed proportions with a flared inlet and may be as high as 200 per cent for

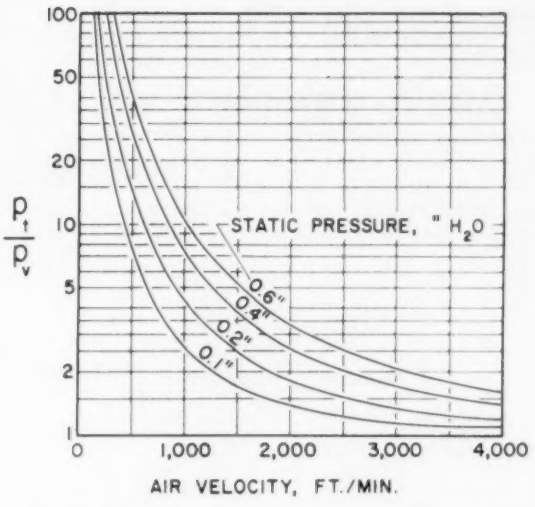


Fig. 9—Chart for determining total pressure/velocity pressure ratio

a sharp edge orifice mounting. The usual commercial design of cooling tower fan cylinder will have a static pressure loss in the order of one quarter of a velocity head at the cylinder.

Ordinarily, extended stacks as are sometimes used to assist in discharging the humid air at a distance of 20 or 30 feet above the fan will have a negligible effect on the fan performance. If the stack is flared outward some kinetic energy recovery will result, which may be of practical significance under conditions of very low static pressure (say in the order of $^1/_4$ in. of water or less). The method of fan performance estimation presented here may be used with reasonable accuracy, and the static

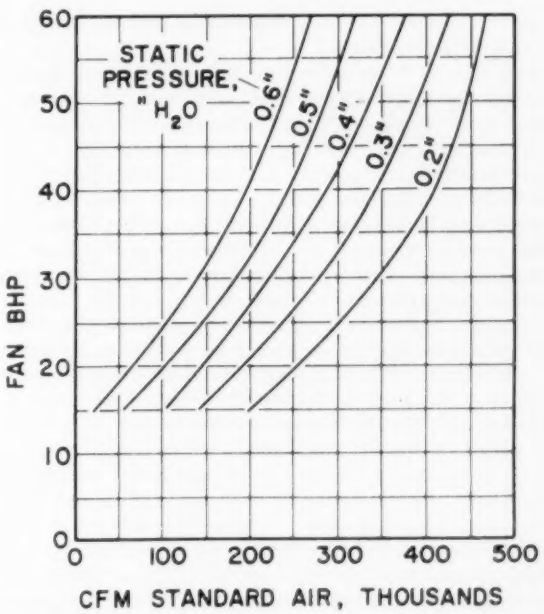
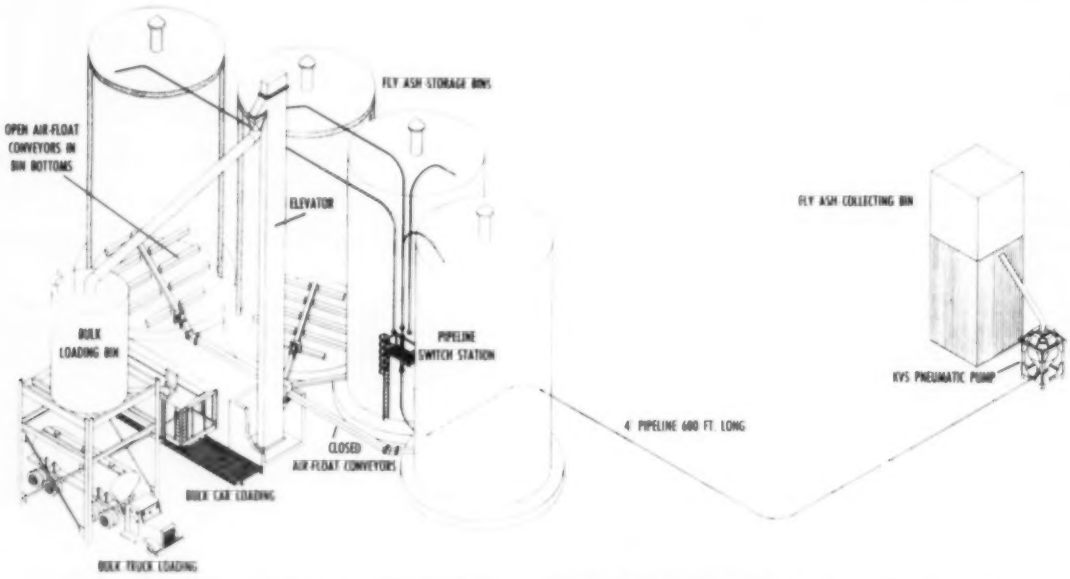


Fig. 10—Performance characteristics of 19-ft diameter 6-bladed fan with 63-in. diameter hub. Based upon 3-ft diameter scale model tested in standard flared wood cooling tower fan cylinder

pressure reduced by the amount of velocity head recovery. It is doubtful that more than about one-half of the kinetic head can be recovered economically.

Summary

A simple method of predicting the performance of cooling tower fans has been presented and compared by example with results of both model and full scale tests. The method may be used to advantage by purchasers of cooling tower fans to determine the validity of performance data presented by prospective suppliers of cooling tower fans. Although the calculated horsepower may be in error by as much as 20 per cent, the predicted air flow will be within approximately six per cent (the cube root of 1.2), which is within field test accuracy. Manufacturers of cooling towers and cooling tower fans have, over the years, indicated accuracies of fan performance and horsepower prediction that are inconsistent within the state of knowledge of the art. The many performance curves permit a ready check on such claims.



Isometric drawing shows layout and arrangement of equipment at Cane Run Power Plant, Louisville Gas and Electric Co.

Flyash Storage Facilities at Louisville Lock Job

The Walter N. Handy Company, suppliers of flyash, for the new Lock at Dam 41 near Louisville, Markland Dam near Markland, Indiana both on the Ohio River and Barkley Dam near Grand Rivers, Kentucky on the Cumberland River, sponsored a tour June 26 of the construction job, the new flyash storage facilities, and the power plant producing the flyash at Louisville, Kentucky. The group consisting of representatives of Corps of Engineers and contractor construction forces concerned with the use of flyash in concrete.

The optional use of flyash in concrete construction was authorized by the Corps of Engineers, only after exhaustive laboratory tests and development of their own specifications. In addition to the physical and chemical requirements, the Corps specifications require that flyash be stored in weather tight bins, for the duration of certain test periods. To meet this requirement the Handy Company, in cooperation with Louisville Gas and Electric Company at its Cane Run Power Plant, installed four 900-ton steel bins. (See Figure at bottom of page.) Facilitating equipment for moving flyash from the power plant some 600 feet to storage and from storage to an elevated loading bin includes a pneumatic pump, conveyors and a bucket elevator. Sampling for the Corps of Engineers acceptance tests is done automatically, as the pneumatic pump is loaded. From each charge of about two tons of flyash going into the pump, the sampler grabs about two spoonfuls. Separate samples, representing each 100 tons stored in the bin, are sent to a Corps laboratory. Approved flyash is loaded into special trucks, which haul about 20 tons per load, to the concrete batch plant at the Louisville job site. The loading facilities are so located that railroad covered hopper cars may be used for distant jobs.

The Hardaway Construction Company, prime contractor on the Louisville Lock, started concreting operations late in April. A subsidiary of Concrete Supply Company, Louisville, subcontractor for the concrete, has set up a batching and central mix plant at the job site. The job is expected to require about 15000 tons of flyash over a two-year period.

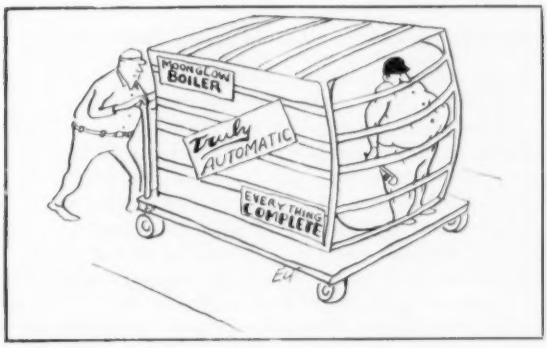
Correction Notice:

In the July 1959 issue, page 37, the sectional views, Figs. 2 and 4, of the "*Combustion of Crushed Dried Texas Lignite and Char in Steam-Power Boilers*" by Caracristi and Mumper should have been interchanged. We thank the many readers who called this to our attention.

Automatically Fired Boilers in Industry Need Some Attendance*

By W. B. PARKER†

Here is a timely warning that push button operation of industrial boilers behind closed doors is not yet an accomplished fact. The conclusions and recommendations are applicable to all sizes and types of boilers and should be of particular importance to those concerned with the design, selection and operation of both slightly and highly automated firing and control systems.



THOSE responsible for the management of industrial plants frequently ask why power engineers and others recommend more or less constant attendance on power boilers operating in such plants when the characteristics of the boilers, particularly in the smaller plants, are so similar to those of automatically fired boilers which are used for heating purposes in residences, apartment houses, small stores, etc. Since they operate satisfactorily month after month with a minimum of expert attention while requiring major servicing only once or twice a year, it is logical that the question should be asked.

The reasons given may vary widely, depending upon the power engineer's personal experience with boilers of various sizes and kinds, and the requirements of local state codes, rules, or regulations, and existing operating engineers license laws. Some of these regulations specify constant attendance, regardless of the number of automatic devices provided on the boiler. Where such regulations are enforced, compliance is necessary, leaving no choice to the power engineer or to management.

There has apparently been some misconception that insurance companies favor and require constant attendance on all high pressure boilers, regardless of size, use, or other factors.

This may have been true some years ago but the development of dependable automatic controls has changed the present picture considerably.

Constant Attendance Required on Early Steam Boilers

In the early days of steam boiler operation when all boilers were hand fired with wood or coal and when there were no automatic controls, regulators, or warning devices to assist the fireman in his duties, the operation of the boiler involved so many tasks it required his complete attention. It was necessary that he provide sufficient fuel to the boiler to satisfy load requirements, keep the fires clean and, in addition, watch the water level which he usually maintained by the use of a manually-operated inspirator or injector.

As more power was demanded by industry, and as steam began to replace water for power purposes, operating aids were developed which allowed the operator to divide his attention between several boilers or to handle a much larger one. These early operating aids were automatic feedwater regulators, designed to maintain the water at the proper level in the boiler, and high and low water alarms, which alerted the operator if the water became too high or too low.

The development of such regulating and warning devices and also the stoker for coal-fired boilers made it possible for the operators to handle several boilers or a boiler of greater capacity. However, even with these devices constant attendance was necessary. It was during this period that regulations for constant attendance were considered necessary and written into state regulations and license laws.

The introduction of oil and gas, and eventually pulverized coal, as fuel, initiated a new era in the operation of boilers. The increased use of these fuels had far-reaching effects on the generation of steam for power, and on industry generally.

Before the era of the large steam electric generating plants, it was necessary for most industrial plants to supply their own power by the operation of several boilers that provided steam for steam engines or relatively small turbine generators with the exhaust steam or high pressure steam directly from the boiler being used for process and heating.

The development of the large central station allowed

* Reprinted from The Locomotive, April 1959.
† Asst. Chief Engineer, Boiler Division, The Hartford Steam Boiler Inspection and Insurance Co.

most of the industrial plants to purchase electricity for power purposes and to generate steam for process and heating needs only. Many plants shut down their power generating equipment and continued to use the existing boiler equipment for merely process steam and heating purposes. This meant, in many cases, that the boiler operating staff was retained and continued to operate as before. Often this resulted in inefficient operation because the steam generating equipment was much larger than needed. However, as the equipment was serviceable and replacements would have been costly, the use of existing boilers then seemed to be expedient.

Development of the "Automatically Fired" Boiler

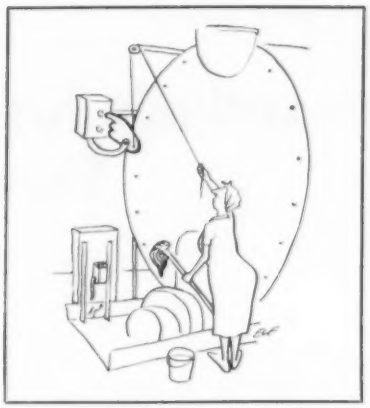
As mentioned previously, the availability of outside electric power changed the power picture for the average industrial plant tremendously as the need for large amounts of steam for power generation was then not necessary. This caused the boiler in the average industrial plant to be used for process and heating only.

These developments eventually encouraged boiler manufacturers to place on the market a new type of boiler which became known as the "package unit." It was designed as a single unit with the boiler and all operating auxiliaries, including controls, furnished by a single manufacturer. Usually the boiler was assembled complete in the manufacturer's plant and tested operationally before being shipped to the purchaser's premises.

Although this type of boiler made its debut before World War II, the ready availability of good operators during those latter years of depression and generally poor business conditions, slowed to a great extent industry's conversion to such units.

In some cases the controls used on these earlier boilers were not all that could be desired, and some cases of poor operating experience resulted. However, during the war years the shortage of good boiler operators, created partially by the development of a considerable number of new industrial plants manufacturing war materials and partially by seasoned operator's going into more lucrative wartime jobs or into the armed services speeded the development of automatic operating controls for boilers. The demand for automatically-operated units for the relatively small plant grew, and the package unit began to come into its own.

As more boiler manufacturers developed package units, the shortage of manpower generally and boiler operators specifically led manufacturers of package boilers to state that their units were "fully automatic" in operation. It was not unusual for folders advertising this type of unit during this period to contain rather broad statements indicating that the boiler was fitted with all controls necessary for *completely automatic operation*, and that by a mere pushing of the starting button, the unit was in operation without preparation and without any further delay. While many of the advertising folders qualified their lead lines, it appears that many salesmen indicated that the equipment was fully automatic in operation and required no attention whatsoever. This was evidenced by the fact that in many cases where a boiler of this type was first installed an insurance inspector found that the owner was definitely of the impression that all that was required to operate his "packaged unit" was a push of the



"start" button in the morning and a push of the "stop" button in the evening when the day's operation was completed.

The inadequacy of this type of operation soon became apparent as the complete lack of attention and maintenance resulted in failures of the automatic controls. Sometimes the results were furnace explosions, scaling of the internal surfaces (particularly when only a low percentage of the condensate was returned to the boiler), and the development of low water damage because of failures of the automatic water level controls and low water fuel cutouts.

Because of this poor experience, insurance company representatives discussed with the manufacturers the difficulties with these automatically operated units. The manufacturers readily recognized the weaknesses in their advertising literature and the problem created by their over-enthusiastic salesmen indicating that the boilers needed little or no attention in operation. As a result the tone of their advertising was changed as were their instruction manuals.

The trend today in such advertising is to indicate that this type of unit is automatic in operation, being provided with certain controls and protected against flame failure, low water damage, excess pressure, motor overloading, short circuits, and other operational hazards by the best obtainable safety equipment. The advertising further states, however, that while these operating controls reduce the boiler attendant's time to a minimum, the unit requires periodic checking. In most cases, a service engineer visits the plant at the time the boiler is installed, determines that the boiler is properly connected, and actually spends some time with the operator, giving instructions in the proper operation and maintenance of the boiler and operating controls. It is this new approach that raises questions regarding the amount of attendance required. Before discussing the question further it may be desirable to briefly consider the controls required for automatic operation.

Operating and Control Devices Required for Automatic Operation

While coal-fired boilers can be equipped with some automatic control devices, usually it is not practical to make them fully automatic, since the coal supply and auxiliaries supplying the fuel require attention. Oil and gas are the usual fuels for completely automatic boiler operation as they can be cut off instantly in the event of

an impending low water or other undesirable condition, to allow the temperature in the boiler furnace to be reduced quickly.

The automatically-operated oil or gas-fired boiler should be equipped with certain minimum operating controls where applicable:

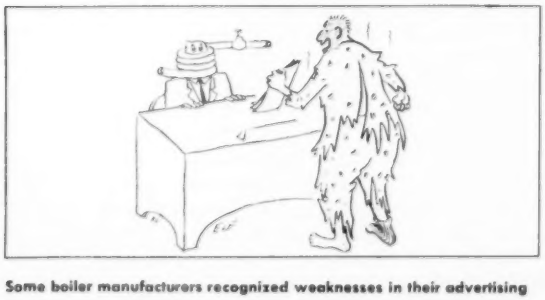
1. Pressure control.
2. Low gas pressure cutoff.
3. Low oil temperature interlock.
4. Flame failure control.
5. Feedwater regulator or water level control.
6. Low water fuel cutoff.

Each of the above mentioned control devices, with the exception of the feedwater regulator or water level control, should be adjusted to shut off the fuel supply or the firing mechanism should some unsatisfactory condition develop, and to sound an alarm and lock out the electrical control until it is manually reset. These devices should also be so designed and installed that they will "fail safe." In other words, should anything happen to the device itself, it should automatically shut down the firing mechanism until it can be checked out by the attendant.

Periodic Attendance Necessary

With these automatically-operated devices, constant attendance of the average small industrial type boiler is not necessary. However, it is essential that the boiler be attended at regular intervals, to determine the condition of the automatic operating equipment and the boiler itself. The length of time between such checkup periods will vary considerably with the equipment involved. *Obviously, the check should be made by a fully qualified operator who understands the purpose, method of operation, and method of checking the automatic devices.*

The period between visits by a qualified attendant will vary with the size and the water capacity of the unit involved and the load to which it is subjected. One suggested criterion for determining the length of time between checkups has been that length of time in which water in the boiler would drop from a normal level down to a hazardous level should the feedwater supply fail. This will not suffice in all cases, as in many steam generating units there is very little reserve water capacity. The length of time between visits by qualified personnel is a matter that should be determined for each specific installation by management, the operating personnel, and the insurance inspector. It is impractical and impossible to set up hard and fast rules. If there is doubt, the frequency of attendance should be high until experience is obtained with the operating characteristics of the installation. Nearness of the operator to the boiler room, and nature of his other duties are other factors that must be given consideration. Where the presence of the operator is required at considerable distances from the boiler room, strategically placed remote alarms are useful.



Some boiler manufacturers recognized weaknesses in their advertising

Testing and Maintenance of Control Devices

It has been appropriately stated that automatic operating and control devices are only as good as the attention and maintenance they receive. *To determine that they are in satisfactory operating condition, they should be tested at least once a day, or once at the beginning of each shift if the boiler operates at periods of longer than eight hours. More frequent checks may be desirable if the operation of the boiler is such that the automatic devices are cycling at frequent intervals.* (Italics are the Editor's). The tests should be so conducted as to simulate actual operating conditions as far as possible. As an example, in testing a float type low water fuel cut-out, the float type low water fuel cut-out, the float bowl should be drained slowly, as low water conditions also develop slowly. The bowl should then be blown down thoroughly to flush out any accumulated sediment.

In addition to frequent checks to determine that this type of equipment is functioning properly, it is important that it be completely overhauled, cleaned, and checked out at regular intervals. Frequent checking also helps prepare operators for emergencies. A schedule should be set up for the proper inspection of this equipment by a service engineer, factory representative, or other qualified person. This schedule should include at least the following:

1. Check all wiring to the units for grounds and for tightness of wiring connections.
2. Check contactors, switches and relays, for smoothness of operation and proper alignment of the contacts. Any worn or burned contacts should be replaced.
3. Determine that all control enclosures are free of dust and dirt and that the covers are kept on and the working parts maintained in dust free condition.
4. Completely dismantle the feedwater regulator or water level control and/or low water fuel cutoff to determine they are in satisfactory operating condition. Some of the difficulties commonly found are:
   (*a*) Accumulations of sediment in the bottom of the float chamber.
   (*b*) Scale or barnacle-like deposits adhering to the internal surfaces that may interfere with the action of the float.
   (*c*) Damaged float or float arm.
   (*d*) Worn or corroded shaft in stuffing box, and too tight or hard stuffing box packing.
   (*e*) Defective or loose mercury tube switches.
   (*f*) Cracked or otherwise defective sylphon bellows.
5. Examine all steam and water lines to controls to determine that they are clear of scale and arranged to insure proper operation.
6. Determine that all controls and connecting lines are protected from freezing.
7. Examine all control valves in fuel lines. Dismantle if necessary, to determine that they are in good condition.

The length of time between scheduled checking and overhaul periods will depend upon several items:

1. Number of hours per day operation.
2. Load to which boiler is subjected.
3. Frequency of operating cycle.
4. Recommendations of the manufacturer.
5. Experience obtained by operation.

The most satisfactory method of obtaining accurate information on which to base a proper testing and maintenance schedule is to keep a complete log of the boiler

CHECK BOTH

OXYGEN
in the feedwater

HYDROGEN
in the steam

Oxygen is well known to be an active source of boiler corrosion. The oxygen dissolved in feedwater is determined directly and continuously recorded upon the Cambridge Dissolved Oxygen Recorder.

The oxygen set free by dissociation of the water in the boiler is equally damaging. Its presence is determined by measuring the free hydrogen in the steam condensate.

Cambridge Analyzer-Recorders provide continuous records of both the oxygen dissolved in the feedwater and the hydrogen in the steam—on one chart if desired, thus enabling prompt corrective measures to be taken.

Complimentary Copies of these bulletins will be sent upon request.

A.S.T.M. BULLETIN D1588-58T

Describes the approved referee method of testing for gaseous hydrogen in industrial water.

CAMBRIDGE BULLETIN NO. 148 BP

Describes both the CAMBRIDGE Dissolved Oxygen and Dissolved Hydrogen Analyzers.

Instrument shown may be used to record either O_2 or H_2 or both simultaneously. Cambridge also makes Hydrazine Analyzers, PH Recorders and instruments for analyzing gaseous mixtures.

CAMBRIDGE INSTRUMENT CO., INC.
3549 Grand Central Terminal, New York 17, N. Y.

CAMBRIDGE
Dissolved O_2 & H_2
ANALYZERS

Pioneer Manufacturers of Precision Instruments

operation. This log should provide a record of at least the following:

1. Hours of operation.
2. Record of the load carried at regular intervals.
3. Pressure.
4. Record of tests of all operating and control devices and conditions found as result of tests.
5. Complete record of conditions found at scheduled overhaul of operating and control devices.
6. Work performed on boiler and auxiliary equipment.
7. Replacement of devices that may have a relatively short life such as mercury tubes in level controls and cells and electronic tubes in flame failure controls.

A properly maintained log will provide reliable information on which to base the length of time between overhauls or replacement of parts.

Conclusions

Based upon experience of this company, the need for some degree of attendance on automatically operated boilers is obvious. Studies of accident-cause-analysis statistics for the years 1956 and 1957 show that 46.9 per cent of the insured accidents (excluding furnace explosions) to high pressure steel fire tube boilers were the result of inadequate testing and maintenance of control devices. During 1958 this figure increased to 52.0 per cent. The 1956–1957 statistics on furnace explosions are also significant. They show that 20.9 per cent of the furnace explosions on oil-fired boilers and 21.5 per cent on gas-fired boilers were due to failure to test and maintain their control devices. Therefore while automatic operating and control devices have been developed to a high degree of operating efficiency and dependability they are still subject to failure, and some attendance is necessary. The extent of that attendance, however, is dependent to a great degree upon a good maintenance and testing program, particularly as respects automatic controls. The frequency of attendance will vary from almost constant in certain plants, to once hourly or possibly even longer periods for others that have a carefully planned and supervised program for testing and overhauling automatic controls, auxiliaries, and appliances. The attendance, testing and overhaul schedule should be established only after careful study and consultation with the boiler inspector. As previously indicated, the rules in state codes, regulations and license laws must be observed where applicable.

Equipment Leasing Program for Closed Circuit Television

What is believed to be the first broad based program for leasing of custom engineered closed circuit television systems was announced here *by* Diamond Power Specialty Corporation, Lancaster, Ohio. Management of lease contract arrangements will be done in cooperation with American Industrial Leasing Company of New York City, according to Mr. Tricebock, Electronics Division General Manager. However, all preliminary arrangements will be made through Diamond Electronics Sales Engineers and Sales Representatives.

Lease contracts may include all standard equipment, standard and specialized accessories as desired, cables, spares, applicable purchase taxes, and shipping and installation charges. Insurance on the installed system is also available at very nominal cost during the lease base period.

Abstracts From the Technical Press—Abroad and Domestic

(Drawn from the Monthly Technical Bulletin, International Combustion Ltd., London, W.C. 1

Fuels: Sources, Properties and Preparation

The Physical and Chemical Properties of Bituminous Coal Macerals. X. Autoxidation and Chemical Constitution. C. Kröger and H. Bürger. *Brennst Chemie* 1959, **40** (Mar.) 76–85 (In German).

The oxidation of macerals by molecular oxygen has been studied and the degree of oxidation obtained has been determined tritrimetrically and by weight. The results form the basis of formulae of constitution of the three original macerals and their oxidation products. The characteristics differentiating the macerals are oxygen bonding, number of methyl groups and the length of the alkyl groups.

Coal Ash Slags. Pt. I. Formation and Mineralogy. J. D. Watt. *B.C.U.R.A. Month. Bull.* 1959, **23,** (Feb.) 49–69

A detailed review of the subject is presented under the headings: 1. Introduction; 2. Thermal decomposition of clay minerals; 3. Thermal decomposition of other coal minerals; 4. Further reactions of initial decomposition products; 5. Examination of solid slags; 6. Classification and description of minerals in slags; 7. Application of phase diagrams to the study of slags; 8. Value of mineralogical examination of slags; 9. Bibliography (127 references).

The Gasification of Solid Fuels Under Pressure. O. Hubmann. *Brennst Chemie* 1959, **40** (Mar.) 65–73 (In German).

A review of the development of pressure gasification of brown and bituminous coal by the Lurgi process and a brief description of the plants in South Africa (SASOL), Dorste, Australia (MORWELL), Scotland and Korea.

Pressure Gasification of Fuels. H. Pichler. *Brennst Chemie* 1959, **40** (Mar.) 71–3 (In German).

A brief review of pressure gasification processes other than the Lurgi process.

Recent Results of Pressure Gasification of Bituminous Coals in the Gas Producer Plant of the Steinkohlengas A.G. Dorste. H. Weittenhiller. *Brennst Chemie* 1959, **40** (Mar.) 73–5 (In German).

The gas producers at Dorste have each a capacity of 400,000 m³/day of gas including the natural gas used for carburation. The plant is very flexible so that its daily production can be varied between 200,000 and 1,900,000 m³. Modifications in design are described which have contributed to the increased production. This has led to an increase of the output from initially 225,000 m³ to 315,000 m³ and lately to 385,000 m³/day (70 per cent) with an increase of coal throughput of 55 per cent and of oxygen consumption of 45 per cent. The decrease in cost of gas production is mainly due to the introduction of "dry" operation in which the consumption of steam decreased from 1.51 to 0.88 kg/N m³ clean gas. The importance of the by-products to the economics of the plant is indicated.

Economic Coal Transport for Small Boilers. H. Jaissle. *Energie and Tech.* 1959, **11** (Jan.) 47 (In German).

The completely automatic and dust free plant consists of: 1. A movable band conveyor taking the coal from a tipping lorry to the underground bunker; 2. A screw conveyor moving the coal to a bucket chain conveyor; 3. An enclosed conveyor under the boilerhouse roof receives the coal and transports it to a bunker from which it falls via a scale into the boiler hopper. The starting and stopping of the plant is controlled by level sensing probes in the hopper.

Heat: Cycles and Transmission

Simplify Heat-loss Calculations. C. R. Kise. *Power* 1959, **103** (Apr.) 78–81.

Nomograms are presented to simplify calculations of heat loss by radiation, forced and natural convection from flat and cylindrical surfaces.

The Influence of Disturbances at the Inlet and of Natural and Artificial Surface Roughness on the Heat Transfer to Water. G. Grass. *Chem. Ing. Tech.* 1959, **31** (Mar.) 163–5 (In German).

The studies have shown that small periodically applied artificial roughening of the inside of the pipes increases the heat transfer to water but affects the pressure drop very little.

The Mechanism of Heat Transfer to Heat Exchangers in Fluidized Beds. R. Ernst. *Chem. Ind. Tech.* 1959, **31** (Mar.) 166–73 (In German).

The influence of size, contact time and velocity of the solid particles and of the thermal conductivity and pressure of the gas on heat transfer in the moving and the fluidized bed has been studied. The results are presented in graphs and discussed.

Simultaneous Heat and Mass Transfer in Cooling Towers. Pt. II. W. J. Thomas and P. Houston. *Brit. Chem. Engng.* 1959, **4** (Apr.) 217–22.

The analysis and interpretation of experimental results are discussed. (Pt. I see abstract 4445, March 1959.)

Steam Generation and Power Production

Calculation of the Entry Velocity of Water into the Riser Tubes of Natural Circulation Steam Generators. J. Dingler. *Energie* 1959, **11** (Mar.) 107–9 (In German).

It is shown that this calculation can be simplified by using the specific volume instead of the specific gravity of the mixture as was done in the paper by T. Schröder (abstract 3843, 1958).

"Thermiatrics" The Disease of High-Temperature Boilers. D. E. Noll. *A.S.M.E. Preprint* No. 58-A-277 1958 (Dec.) 6 pp.

A review devoted to an analysis of the literature on the diffusion theory of iron oxide formation inside and outside the tubes of high temperature boilers and the effect of heat transfer on the growth of the oxide layer. It is believed that only the replacement of carbon steel by metal more resistant to attack will alleviate the difficulties caused by the building up of the oxide layer.

Steam Generators. R. Quack. *BWK* 1959, **11** (Apr.) 168–71 (In German).

This review of the German and foreign literature of 1958 shows that the rapid developments of previous years has been followed by a period of consolidation to enable experience to be gained from recent installations. It is believed that in future the economics of new plants will have to be considered more closely than previously.

Five Years' Experience on the Consolidated Edison System with Protection of Turbine Generators and Boilers by Automatic Tripping. W. C. Beattie, H. A. Bauman, J. M. Driscoll, P. T. Onter Donk and R. L. Webb. *J. Engng. for Power* 1959, **81** (Apr.), 133–41.

A report of actual operating experience and the functioning of the

system, troubles experienced and design changes found necessary for new units.

Chapelcross. How It Differs from Calder Hall. T. C. Leader. *Atom. Energy Engr.* 1959, **13** (May), 256–60.

Differences in general layout of the reactors, cooling towers, turbine house and ancilliary buildings compared with Calder Hall are presented as well as those in foundations and building design. Other changes are of minor nature.

Three Years' Operational Experience with a Pulverized Coal Fired Hot Air Gas Turbine. H. Kress. *BWK* 1959, **11** (May), 223–33 (in German).

The results over three years' operation of the plant (see abstract 1094, 1956) have been very satisfactory. Operation parallel to and independent of the network provided no difficulties, in both cases the plant was able to follow quickly any load fluctuations. Operating at low electric load and high heat load does not reduce the thermal efficiency but it is important not to exceed the maximum air temperature of 660 C. Minor difficulties were experienced with the compressor blades but these could be overcome by slight changes in design. Design changes of the air heater also proved necessary. The heat exchanger had a larger pressure drop and higher temperature difference than calculated due to fabrication faults and it is to be replaced by one of the same design but improved manufacture.

Fuel Firing

Bituminous Coal Firing. A. Bachmair. *BWK* 1959, **11** (Apr.) 172–3 (In German).

The installation of slagging furnaces (55 per cent of all p.f.f. boilers) is continuing mainly to obtain the ash in a more useful form, especially where coals of high ash content have to be fired. Attention is being paid to improving burner and furnace design to reduce deposit formation and corrosion.

Use of Flow Models for Boiler-Furnace Design. R. W. Curtis and L. E. Johnson. *A.S.M.E. Preprint* No. 58-A-120 1958 (Dec.) 7 pp.

The use of two and three dimensional open and closed channel water models for the investigation of flow pattern of gases in furnaces and superheaters and the conclusions to be drawn from such model tests are set out. In particular, the use of models for developing the most suitable design of the Philo supercritical cyclone fired boiler (shape of furnace, arrangement of heat transfer surface, method of introducing recirculated gases into the furnace) is described.

Water-Side Corrosion and Water Treatment

Some Physico-Chemical Phenomena in Supercritical Water. N. L. Dickinson, W. A. Keilbaugh and F. J. Pocock. *A.S.M.E. Preprint* No. 58-A-267 1958, (Dec.) 9 pp.

Investigations on the pilot plant have shown that maximum deposit formation from the water and maximum overheating of tubes occurs along the critical isochore (line of constant specific volume passing through the critical point) dividing the supercritical region into one of liquid-like and one of gas-like properties. It is also shown that when taking samples of water at high pressure by pressure-reducing valves dissociation of the water occurs leading to errors in determining the true values of dissolved oxygen and hydrogen.

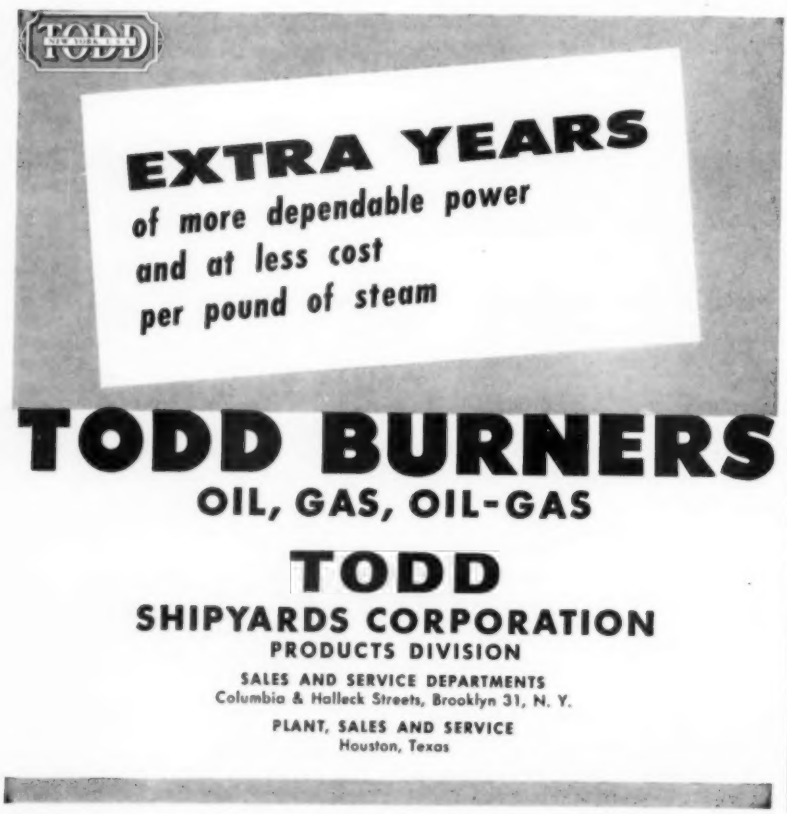
Filming Amines Serve Tough Corrosion Problem for Make-Up System. M. E. Osmond and E. Q. Welder. *Pwr. Engng.* 1959, **63** (Mar.) 75–6.

At the National Works, National Tube Division of the U. S. Steel Corp., a large amount of the steam produced is desuperheated and reduced in pressure from 850 to 150 psi and 450 F by condensate obtained from the low pressure feed water preheater in which the steam from the blow-down flash tank is condensed. The rate of corrosion by dissolved CO_2 in these preheaters and pipe lines amounted to 1285 mg/dm²/day. Addition of filming amines at a rate of 4 ppm reduced this to less than 1 mg/dm²/day. Present practice is a feed of 3 ppm which has effectively arrested all corrosion.

One Utility's Experience with Filming Amines. J. P. White. *A.S.M.E. Preprint* No. 58-A-262 1958 (Dec.) 7 pp.

Filming amines have proved superior and cheaper than neutralizing amines in the boilers of the Arkansas Power and Light Co. in eliminating copper pickup and reducing iron pickup. Owing to its cleaning action and tendency to bind iron and copper oxides into a sticky mass in the low temperature part of the system these oxides can be collected and removed before they enter the boiler.

Trace Concentrations of Octadecylamine and Some of its Degradation Products. G. L. Hopps, M. E. Getz and A. A. Berk. *A.S.M.E. Preprint*



No. 58-A-264 1958 (Dec.) 8 pp.

The use of filming octadecylamine for controlling corrosion in return lines of heating plants has proved less successful than in industrial application because it is unstable in heating systems and decomposes into dioctadecylamine and ammonia. Chemical methods for determining the three substances are described.

Experience with Cyclohexylamine in the Condensate-Feed Water System of High-Pressure Boilers. I. B. Dick and P. C. Fritz. *A.S.M.E. Preprint* No. 58-A-263 1958 (Dec.) 15 pp.

Experience with neutralizing amines used in two 900 psi boilers for 5 years, two 1750 psi boilers for two years and one 2020 psi boiler for some months is reported. The amount used was adjusted to obtain a pH of 8.8–9 at the hot well. Iron and copper concentrations in the feedwater have been substantially reduced and the deposits of iron and copper in boiler tubes have also tended to decrease.

Treating Water for Nuclear Reactors. C. T. Dickert, R. Hetherington and C. F. Raines. *Power* 1959, **103** (Apr.) 69–71.

This second part deals with actual methods for the removal of solids and oxygen from pressurized water at high flow rates and temperatures of 400–600 F. (1st part see abstract 3974 1958.)

Organic Acids for Cleaning Power Plant Equipment. C. M. Loucks, E. B. Morris and E. A. Pirsh. *A.S.M.E. Preprint* No. 58-A-282 1958 (Dec.) 8 pp.

The use of inhibited hydrochloric acid for cleaning the supercritical boiler Philo No. 6 was considered risky because of possible damage to the austenitic material although the austenitic superheater was to be excluded from the cleaning operation. Formic, citric and tartaric acid were teste in laboratory studies and tartaric acid eliminated because it formed an insoluble reactive product which crystallized on the metal surfaces. In field tests formic and citric acids were equally successful in removing deposits but the rinses after citric acid cleaning were free from precipitated sludge. For this reason 3 per cent inhibited citric acid was finally chosen as agent for both initial cleaning and cleaning after 4000 h of operation of the Philo Boiler. The reaction was complete at the end of 3 h; during the second cleaning the 3% citric acid was completely consumed in this time and tube specimens showed complete removal of all deposits.

Gas-Side Corrosion and Deposits

The Prevention of Steel Stack Corrosion and Smut Emission with Oil-fired Boilers. H. A. Blum, B. Lees and L. K. Rendle. *J. Inst. Fuel* 1959, **32** (Apr.) 165–71.

Emission of smut from steel stacks and low-temperature corrosion has been prevented by raising the metal temperature above 250 F by lagging and shielding the metal from wind and rain. The chimney has been given a plain aluminium sheath leaving a $^1/_4$ in. radial gap thus reducing heat loss by conduction and radiation.

A Curtain Type Grit and Dust Arrestor. Anon. *Engng. Boil. Ho. Rev.* 1959, **74** (Apr.) 109–10.

The "Allen-Dep" dust and grit arrestor consists of profiled sheet metal strips forming grids in staggered arrangement across the gas flow. A development of this equipment is its combination with electrostatic precipitators where a number of grids serve as preliminary arrestors of coarse dust, a negative electrode to charge the remaining dust particles and a further number of grids serve as positive electrode. This type is most useful for p.f.f. boilers.

New Process Makes Light Weight Aggregate from Molten Boiler Slag. Anon. *Pwr. Engng.* 1959, **63** (Mar.) 76.

Dow Chemical Co. have developed a process for producing expanded slag from wet-bottom furnace slag which has a cellular structure and is useful as a mineral aggregate for light weight concrete blocks. The expanded slag is crushed and screened to obtain a coarse (+4 mesh) and a fine (−4 mesh) size. A mix for a concrete block with a 28 day compressive strength of 1300 psi consists of 1 part cement, 2 parts coarse and 3 parts fine slag.

Building Materials from Pulverized Fuel-Ash. C. Hobbs. *Brit. Chem. Engng.* 1959, **4** (Apr.) 212–6.

A review of some papers dealing with the subject.

Heat Recovery Plant

Fouling and Cleaning of Power-Plant Heat Exchangers. C. E. Brune and T. A. Miskimen. *A.S.M.E. Preprint* No. 58-A-289 1958 (Dec.) 5 pp.

Fouling and cleaning of feedwater heaters are discussed with regard to: 1. Annual fuel costs of one degree F

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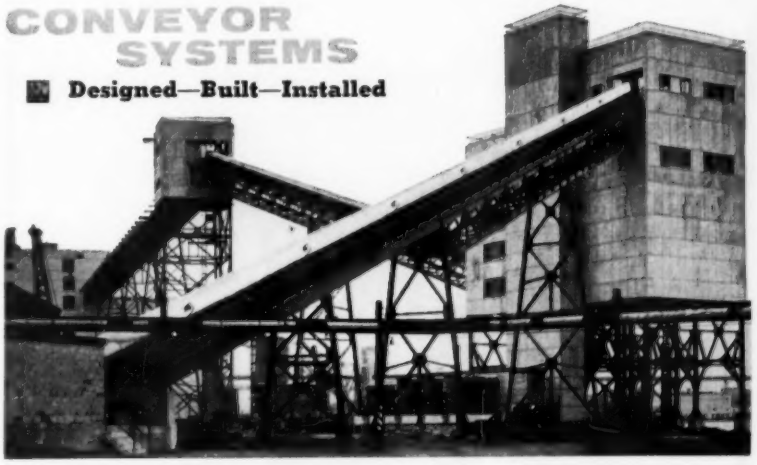

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increase in terminal temperature difference; 2. Inclusion of cleaning facilities in original design; 3. Chemical cleaning economics; 4. Frequency of cleaning; 5. Types and locations of fouling; 6. Chemicals and powders used for cleaning.

Hydraulic Jetting Tools for Cleaning Heat Exchangers. B. L. Canaday. *A.S.M.E. Preprint* No. 58-A-217 1958 (Dec.) 8 pp.

Cleaning tools utilizing high pressure water jets to remove deposits from regenerative air preheaters and shell and tube side heat exchangers have proved quicker and more thorough in cleaning and make possible deposit removal not accomplished by other methods. The design and application of these tools is described.

How to Weld Copper to Stainless Steel and Mild Steel. H. B. Bott. *Weld. J.* 1959, **38** (Mar.) 236–8.

Because of the need in nuclear energy applications for combining the strength and corrosion resistance of stainless steel with the electrical conductivity and corrosion resistance of copper, a joint design and welding procedure are described which have produced satisfactory welds between these two metals.

Instruments and Controls

Supercritical Pressure: A New Control Problem. L. E. Stewart. *Power* 1959, **103** (Apr.) 63–8.

The differences in the control systems for boiler-turbine plants operating at subcritical and supercritical pressure are outlined.

Automating Steam-Atomizing Burners is Practical, Saves Money. R. J. Bizzell. *Pwr. Engng.* 1959, **63** (Mar.) 66–7.

Automatic control systems for oil fired shell-type and small water-tube boilers are described. Attention is drawn to the necessity for correctly sighting the flame failure scanner and for the prevention of outside influence on the scanner circuits.

The Use of Process Data on Steam-Raising by Industry. G. Nonhebel. *Steam Engr.* 1959, **28** (Apr.) 219–23.

The kind of data collected in the boilerhouses of I.C.I. Ltd. and their processing to obtain accurate information on the efficiency of their h.p., l.p. and shell type coal and oil fired boilers and the costs of the steam raised are described.

Need for and Requirements of Flame-Protection Equipment for Gas-Oil-Pulverized Coal. J. B. Smith.

A.S.M.E. Preprint No. 58-A-227 1958 (Dec.) 5 pp.

The ability of available instruments to provide the protection needed and some of the special problems common to larger boilers are discussed. It is concluded that flame failure protection consisting of a combination of flame - sensing and combustibles-oxygen gas - analyzer instruments should be recommended for such boilers.

Compatibility of Flame-Failure Equipment with Boiler Controls. R. Forney *A.S.M.E. Preprint* No. 58-A-256, 1958 (Dec.) 4 pp.

It is pointed out that only if the instrument is correctly designed, constructed, installed and maintained can it be expected to provide the needed protection and compatibility with the other boiler controls.

Application of Existing Flame-Protection Equipment to Oil and Gas Burners. W. F. Lange and J. Dunn. *A.S.M.E. Preprint* No. 58-A-279 1958 (Dec.) 4 pp.

The use of flame protective equipment of the photoconductive type and its reliability are discussed. The limits set by the present designs of these instruments are outlined.

Instruments and Controls

Controls of Steam Generators. H. Schink. *Elekwirtsch.* 1959, **58** (Apr. 20), 239–42 (in German).

The planning of the controls required for various types of boilers and the firing-methods used are discussed. Electropneumatic control systems for traveling grates, water level and superheated steam temperature are described.

Control Breakthrough at Little Gypsy. Anon. *Power* 1959, **103** (May), 64–5.

For the 225 MW unit of Little Gypsy station, Louisiana Power and Light Co., has ordered a fully automatic electronic computer control system which performs all starting up, operational and shut-down functions without human assistance. The start-up procedure takes $4^1/_2$ hr and is conditionally and sequentially controlled in 800 steps by measuring 700 temperatures, pressures, flow rates, valve positions and switch points. It also incorporates safety circuits to give alarm or shutdown on over- or under-limit operation. If the computer cannot correct by itself alarms are given and special data printed immediately. Data and computed efficiencies are printed out once an hour.

Internal Inspection of Fast Reactor Fuel Elements. C. D. Reid. *Nucl. Pwr.* 1959, **4** (May), 109–10.

NEW dry-acid cleaners are concentrated, easier to handle, require less storage space. One 100-lb. drum, for example, occupies only 1.9 cubic ft. of storage space – is more than equivalent to a 192-lb. carboy of 18° Be' HCl.

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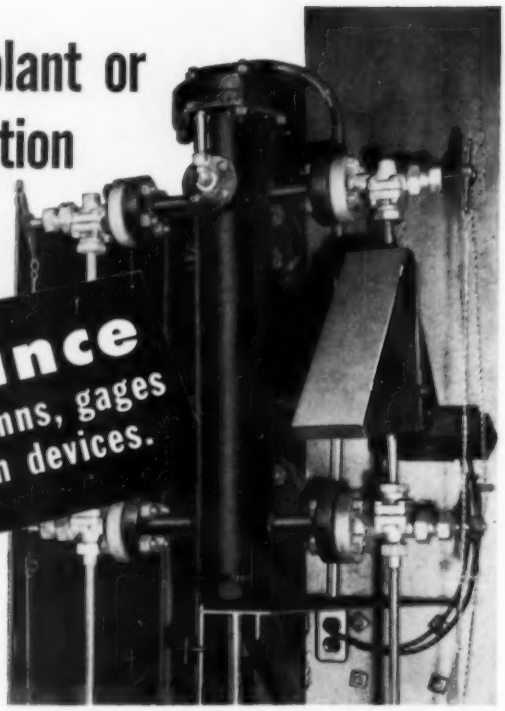

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An introscope incorporating a micrometer (variable inductances) to provide optical inspection of the bore and a measure of its diameter is described.

Non-Destructive Flaw and Corrosion Tester. Anon. *Proc. Contr. Autom.* 1959, **6** (May), 213–5.

The "Introview" tester making use of the properties of eddy currents set up in the material under test is described; it consists of the recorder unit, power pack, probe, probe-injector and probe winch unit. The working of the tester and the interpretation of the recorded traces are explained.

Measuring Wastage of Furnace Tubes F. W. Board and W. A. Topley. *Electr. Times* 1959, **135** (Apr. 30), 692.

An instrument developed at Battersea Power Station is described which enables a rapid check of the wastage of boiler tubes. It has been specially designed for tubes of $2^{31}/_{32}$ in. diam and has an accuracy of ± 0.015 in., but can be easily adapted to other tube diameters.

Corrosion Testing in Chemical Plants. R. S. Thornhill. *Brit. Chem. Engng.* 1959, **4** (May), 280–5.

Instruments for detecting and measurement of corrosion, choice of materials and their testing for given duties are discussed.

Fuel/Air Regulator with Steam/Fuel Control. B. M. Zemtsovskii and P. V. Frolov. *Elekt. Stantsii* 1959, **30** (Feb.), 8–10 (in Russian).

The air regulator described, which has given two years satisfactory service, is devised on the basis of an electro-mechanical-type adjustment column and functions efficiently in the case of abruptly fluctuating loading with fuel of varying thermal and combustion properties. The regulator can also be used in systems where it acts on the fuel and not on the air. In this case boiler load is fixed according to steam pressure.

From *C.E.G.B. Digest* 1959, **11** (May 23), 1233.

Nuclear Energy

Engineering Developments in Nuclear Power. Anon. *Engineer* 1959, **207** (Apr. 3) 528–32.

Abstracts are presented of a paper by A. T. Bowden to the North East Coast Institute of Engineers and Shipbuilders in which engineering problems relating to fuel elements, pressure vessels, gas circulating systems and design of the circulator and its drive were discussed.

Nuclear Energy Production. K. Jaroschek. *BWK* 1959, **11** (Apr.) 157–9

(In German).

The various research reactors in the planning or construction stage are described. The first is a 15 Mw(e) project by BBC/Krupp using graphite spheres incorporating 20 per cent enriched uranium carbide and thorium spheres as breeder material, both without cans, and as coolant a mixture of 78 per cent neon and 22 per cent helium at a pressure of 10 ata. Temperatures in the core will reach 600–1000 C, the steam generated will be at a pressure of 75 ata and 505 C, the net efficiency 30 per cent. The second project by A.E.G. concerns a 100 Mw(e) boiling water reactor containing enriched UO_2 in Zircaloy-2 cans. The third project by B & W is a natural uranium graphite moderated and CO_2 cooled 100 Mw(e) reactor based on British experience. The fourth project by Siemens-Schuckertwerke for a 100 Mw(e) reactor is to operate with pressure tubes containing UO_2 and heavy water as moderator. A 15 Mw(e) reactor is under construction at Kahl containing enriched (2.6 per cent) UO_2 with Zircaloy-2 cans and light water at 73 ata; steam is generated at 46.7 ata. The reactor is to be placed almost entirely underground. The question of the costs of the various projects and the economics of nuclear power production are discussed.

Activity Build-up in PWRs with Stainless Steel Elements. W. H. Zinn. *Nucl. Pwr.* 1959, **4** (Apr.) 109–11.

Investigations carried out in America indicate that the problems of deposition of radioactive corrosion products on portions of the loop outside the core is more serious than anticipated and that equipment for decontamination should be incorporated in future designs.

Nuclear Energy

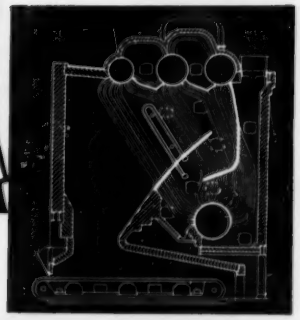
Atomic Review. Thermonuclear Assembly. Anon. *Engineering* 1959, **187** (May 1), 574–6.

Conclusions reached in the papers presented to the British Nuclear Energy Conference on April 29 and 30 1959, are reproduced. These dealt with (1) Thermonuclear criteria; (2) Present state of plasma theory; (3) Mechanism of electron loss; (4) Two basic kinds of fusion device; (5) Containment systems; (6) Fundamental problems outstanding; (7) Direct conversion from pinch machines.

Atomic Review. Thermonuclear Engineering. Anon. *Engineering* 1959, **187** (May 8), 606–8.

The modifications carried out on the original Zeta thermonuclear device are described relating to the liner, torus,

MORE STEAM



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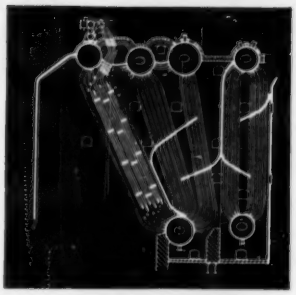

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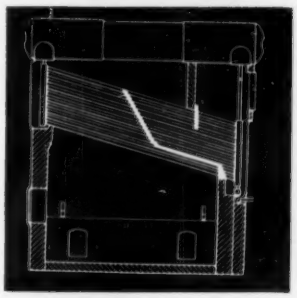

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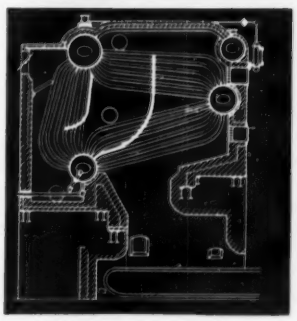

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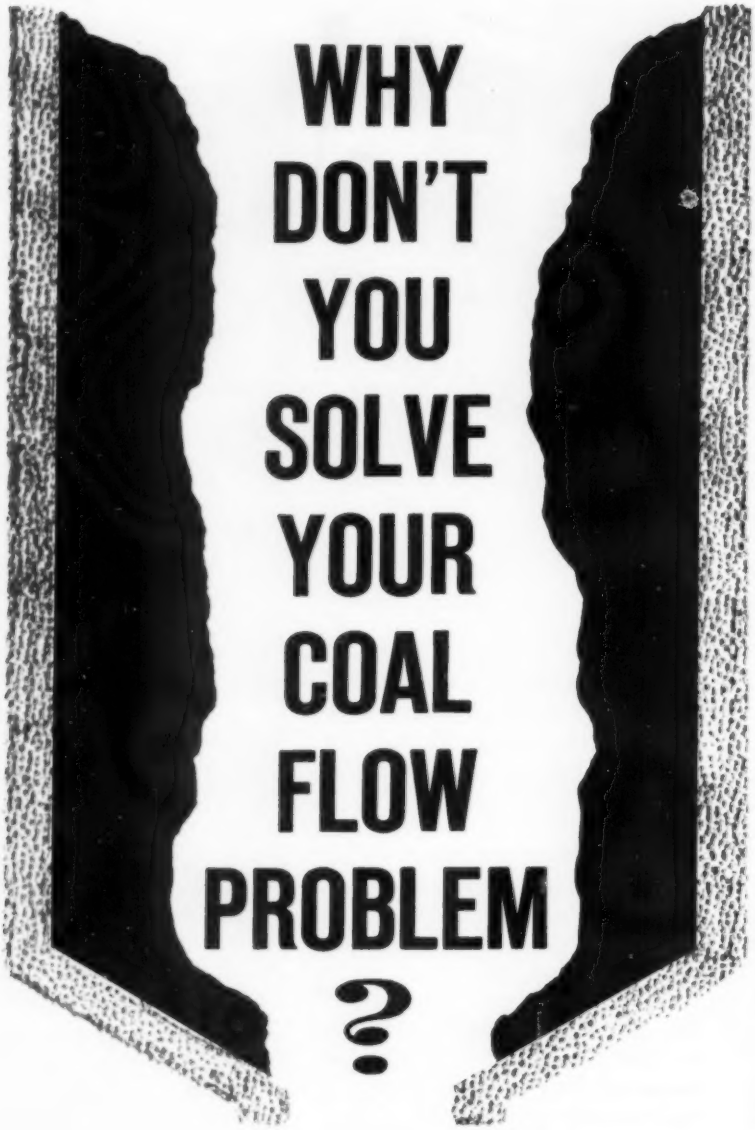

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Recent Thermonuclear Experiments with Sceptre IIIA. Anon. *Engineer* 1959, **207** (May 8), 723–5 (May 14), 760.

Abstracts are presented of the paper by A. A. Ware to the I.E.E. convention on thermonuclear processes in which he described experiments to elucidate electron-particle loss. A mechanism for this loss is suggested.

Tritium Production and Cycling in a Fusion Reactor with Lithium Blanket. K. Hintermann and R. Widerŏe. *Brown Boveri Rev.* 1959, **45** (Nov./Dec.), 588–95.

The possibility of this cycle has been studied analytically and the results are discussed.

Relative Thermal Performance of Carbon Dioxide and Helium in Nuclear Power Cycles. F. E. Tippets. *A.S.M.E. Preprint* No. 59-GTP-14 1959 (Mar.), 9 pp.

A mathematical analysis is presented of a comparison of CO_2 and H_2 as heat transfer media in a nuclear gas-turbine cycle and a gas-cooled reactor-steam turbine cycle. Although the heat transfer area required for H_2 is smaller than that for CO_2 the compressor work is higher and on overall consideration there is no definite superiority of one gas over the other.

Temperature and Reactivity. J. J. Syrett. *Nucl. Pwr.* 1959, **4** (May), 95–7.

The influence of changes of temperature in the fuel and the moderator on the performance of the reactor is discussed.

Choice of Steam Process in Combined Combustion in Nuclear Power Stations. H. Benzler. *Atomkernenergie* 1959, **4** (Feb.), 56–61 (in German).

The superheating of steam generated by a nuclear reactor in a separately fired superheater and the increase in efficiency of this cycle are discussed. It also enables a large measure of control of power output without having to reduce the reactor output.

Thermal Calculation of Gas-cooled Reactors. H. D. Bahr. *Atomkernenergie* 1959, **4** (Feb.), 49–55 (in German).

The second part deals with the calculation of cooling of the reactor, blower output and reactor heat output, net electric output and brings some calculated examples.

The Thermal Design of the Core of a Pressurized Water Reactor. W.

Schopf. *Energie* 1959, **11** (Apr.), 153-7 (in German).

A summary is presented of the results of a study group which calculated the main dimensions and made proposals for the design of a light-water cooled and moderated reactor with the following data: (1) Maximum thermal output 450 MW; (2) Cooling medium exit temperature 280 C; (3) Cylindrical core with height about equal to diameter; (4) Plate-type fuel elements made of an alloy of uranium and stainless steel with a stainless steel sheath or of an alloy of uranium, zirconium and niobium with a Zircaloy-2 sheath; (5) Uranium enrichment less than 3 per cent; (6) Average heat flux 3–4 × 10^4 kcal/m^2, h; (7) Uniform coolant velocity over core cross-section. The main dimensions of the core are given and the optimum design indicated. The calculation of the temperature distribution as a function of the rise of temperature inside the fuel element, of the maximum admissible coolant exit temperature and of the temperature distribution as a function of the radius of the core are presented. The equation for calculating the pressure drop in the coolant channels is given and the thermal stresses in the fuel elements are discussed.

Los Alamos Power Reactor Experiment No. 2. Anon. *Engineer* 1959, **207** (May 8), 747.

This reactor LAPRE-II uses a solution of enriched uranium phosphate, phosphoric acid and water as fuel with natural circulation. The heat exchanger is enclosed in the same pressure vessel. All metals in contact with the solution are clad with gold. The reactor became critical on February 26, 1959.

Marine Propulsion Projects. Anon. *Nucl. Engng.* 1959, **4** (May), 193–6.

A review of recent papers on projects of nuclear propulsion in U. S. A. Denmark, France, Germany, Holland, Italy, Japan, Norway, Sweden and U.K.

N.S. Savannah. Anon. *Nucl. Engng.* 1959, **4** (May), 197–9.

The principal data of the first mechant ship to be powered by a nuclear reactor are presented. The pressurized water reactor has a maximum rating of 74 MW at 1750 psi and contains uranium oxide fuel elements enriched to 4.7 per cent and stainless steel cladding. The core, pressure vessel, controls and primary coolant flow are described in some detail.

A BWR for Merchant Ship Propulsion. R. L. Schmidt and L. F. Fidrych. *Nucl. Pwr.* 1959, **4** (May), 106–8.

The preliminary design by G.E. Co.

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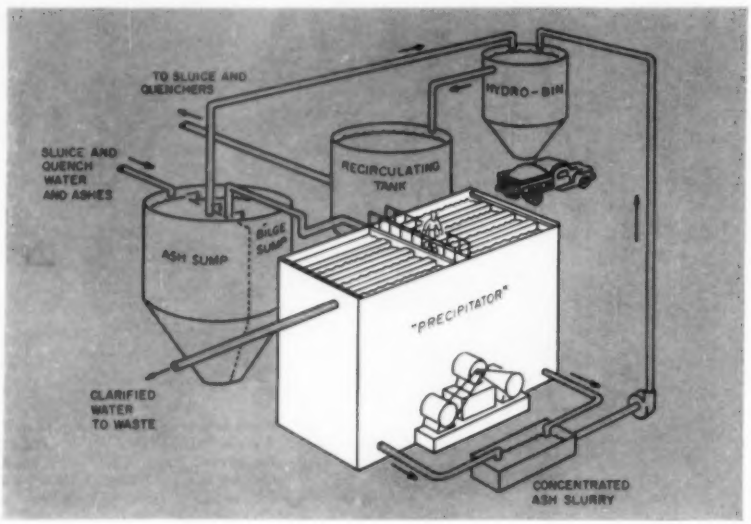

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Ash problems at U. S. Rubber's Detroit plant are typical. The powerhouse has widely varying loads . . . requiring a flexible ash-handling system. The system must also be dependable, because all clarified effluent water goes into the Detroit River and this water must not contain suspended solids that could obstruct the river channel.

Tests were run at U. S. Rubber's plant using a pilot-scale Permutit Precipitator. As a result of these tests, a 300 gpm horizontal unit was installed. (See simplified flow chart.)

U. S. Rubber's Permutit Precipitator goes a long way to make their system successful. In use over 2 years, the Precipitator handles varying loads of 15 to 25 tons of suspended ash per day . . . at low cost without coagulants or other chemicals . . . yet it always delivers effluent water as clean as the river water itself.

Pfaudler Permutit offers impartial advice about water treatment . . . based on experience with all basic types of solids separation processes—coagulation, settling, flotation, centrifuging, evaporation and ion exchange. Write to our Permutit Division, Industrial Waste Treatment Dept. CO-99, 50 West 44th St., New York 36, N.Y.

FLUIDICS covers such varied phases of fluid handling and control as:

water treatment	metering
waste treatment	valving
corrosioneering	flow rate control
fluid analysis	piping
agitation	storing
blending	heat transfer

Whenever you have a fluid-handling problem put the Pfaudler Permutit FLUIDICS program to work.

PFAUDLER PERMUTIT INC.

Specialists in FLUIDICS . . .
the science of fluid processes

of America of a boiling water reactor of 59.7 MW thermal output intended for ship propulsion is described.

Multiplication of Fast Neutrons in Thick Fuel Elements. K. O. Thielheim. *Atomkernenergie* 1959, **4** (Mar.), 89–93 (in German).

The rapid multiplication factor for plane and spherical fuel elements is calculated taking into account the transport correction of the neutron flux.

The Future of Ceramics as Nuclear Fuel. 1. What are Ceramics? N. C. Moore and J. B. Huffadine. *Nucl. Pwr* 1959, **4** (May), 86–9.

The reasons for using ceramic fuel elements are set out and manufacturing techniques described.

The Future of Ceramics as Nuclear Fuels. 2. Development of the New Fuels. P. Murray. *Nucl. Pwr.* 1959, **4** (May), 89–94.

The difficulties of preparing the material from which the fuel elements are made, behavior under irradiation and various types of ceramic fuel elements, viz., uranium dioxide, uranium monocarbide and dispersion or cermets are discussed.

Analysis and Testing, Research

Studies in the Chemistry of the Operation of Solid-fuel-fired Gas Turbines. 4. Examination of Ash Samples from an Open-Cycle Gas Turbine after Running on Pulverized Peat. 5. Dry Corrosion Aspects of Peat-ash Deposition. 6. A Proposed Mechanism for the Deposition and Bonding of Ashes in an Open-Cycle Peat-fired Gas Turbine. J. A. Waddams, J. C. Wright and P. S. Gray. *J. Inst. Fuel* 1959, **32** (May), 241–52.

Studies in Bomb Calorimetry X—Conditions for the Combustion of Solid and Liquid Fuels. R. A. Mott and C. Parker. *Fuel* 1959, **38** (Apr.), 189–204.

Various improvements to obtain better repeatability and accuracy are described.

Direct Oxygen Determination and Its Application in Fuel Analysis. W. Radmacher and A. Hoverath. *Brennst Chemie* 1959, **40** (Apr.), 97–104 (in German).

The direct determination of the oxygen content of coals after removal of the minerals is described. The oxygen uptake of coals of different rank was studied. The effect of oxidation of coal was investigated by noting the changes in the V.M. content, water uptake, C.V. and coking and caking properties. The oxidation inhibiting effect of ammonia could be demonstrated.

Simplified Tablet Tests for Water Used in Steam Generation. A. T. Palin. *Engng. Boil. Ho. Rev.* 1959, **74** (May), 151–2.

The use of tablets for checking the quality of boiler water has been developed to simplify the work of the boiler operator. The tablets give a marked change in color and from the number of tablets used it is easy to obtain the different values; a table facilitates this calculation. On average the error will not exceed ± ½ ppm.

Use of Calibration Blocks for the Control of Ultrasonic Testing Equipment. Intern. Inst. Welding Commission V. *Soudage* 1959, **13** (Mar./Apr.), 149–57 (in French).

A Dutch and a British unit have been compared. A block recommended by the Commission is described which is based on the Dutch block has more practical and universal application.

Personals

Enoch R. Needles, prominent consultant in civil engineering, is the re-elected president of Engineers Joint Council for 1959, by EJC's board of directors. Dr. Augustine B. Kinzel, vice president for research, Union Carbide Corp., is the vice president of Engineers Joint Council.

Engineering consultants **Allen Johnson,** P.E., and **Paul Mulcey,** P.E., serve the Fuel Engineering Co. of New York as associates and have been in this capacity since early this year.

Allis-Chalmers work in atomic energy programs was more sharply delineated when that company early in the year formed a nuclear power department within its renamed Atomic Energy Division. **C. R. Braun** has been appointed manager of the department, according to **Roy M. Casper,** divisional general manager.

General Electric early in the year assigned its top atomic expert, **Francis K. McCune,** vice president and general manager of the Atomic Products Division, to the post of vice president —Atomic Business Development in Marketing Services, to promote the company's position.

O. W. Kayser and **Peter H. Smith** were appointed this year as assistant vice presidents of Gibbs & Hill, Inc., consulting engineers.

Charles Kiel, Jr. was elected vice president, Operating Services, of Long Island Lighting Co. following its annual meeting in late April.

Fred W. Argue, engineering manager and a vice president of Stone & Webster Engineering Corp., was elected executive vice president.

For Top Quality Welding
On Chrome-Alloy Steels

Use CHAMPION CROLOY® ELECTRODES

For top drawer welding of Chrome Moly Steels, **Champion Croloy Electrodes** have excellent handling characteristics in all positions, and produce radiographically clean welds of unsurpassed mechanical properties. **Champion Croloy Electrodes** are available in all of the popular grades from 1¼% Chrome, ½% Moly to 9% Chrome 1% Moly in 3/32" through 3/16" diameter. Only Croloy Electrodes are identified with the Croloy imprint on each Electrode and are manufactured under U.S. patent license.

Champion also offers a full line of Stainless Steel Electrodes in all analyses with either lime or AC-DC coatings. **Champion** is the leading manufacturer of the increasingly popular 16-8-2 composition, which gives unparalled freedom from cracking in type 347 and 316 weldments.

For further information on any of these electrodes, write today.

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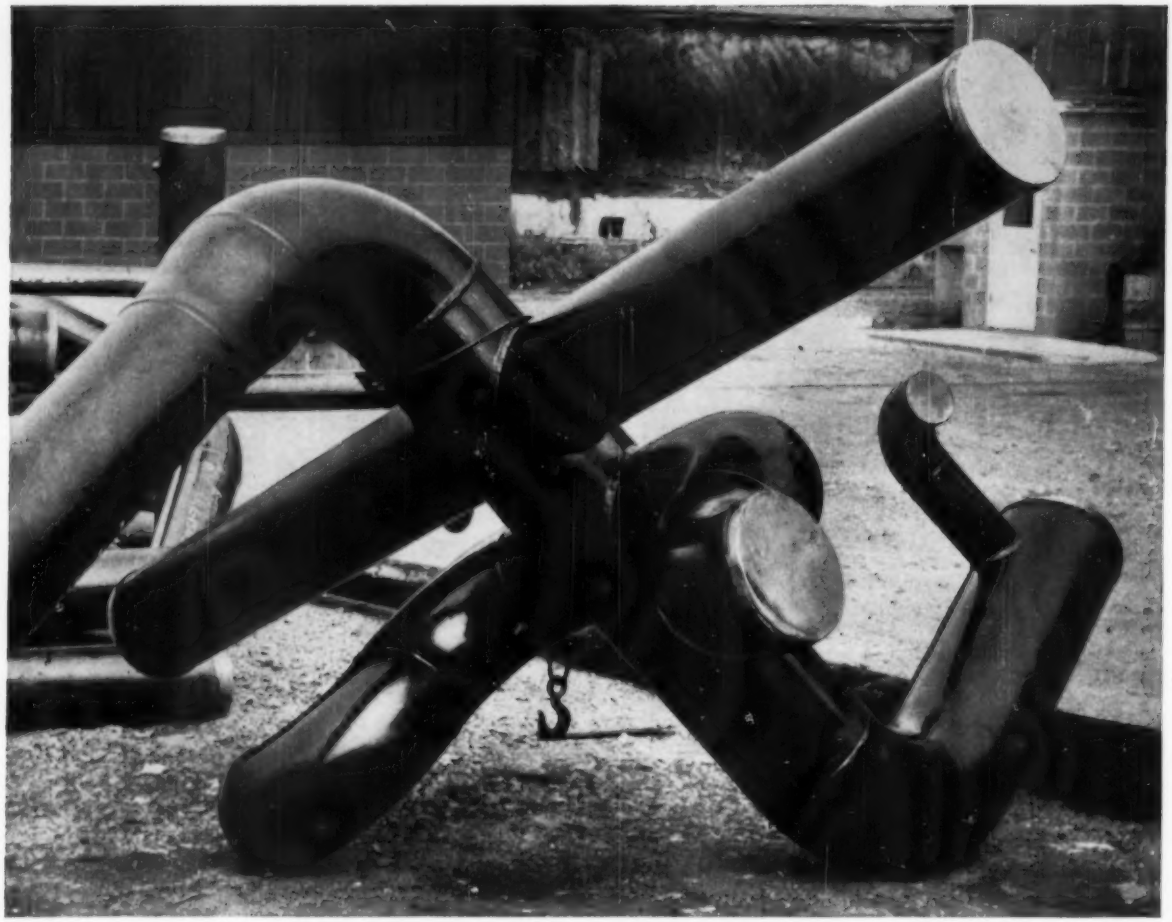
Cleveland 5, Ohio — East Chicago, Ind.



Shop fabrication of complex shapes such as this ⅜" wall service water header simplifies field erection.

Minimum field welding and fitting means faster installation and **lower overall cost of installed piping**

The service water header shown is part of an order which included all piping six inches and larger for a 325MW central station. The boiler will operate at 2000 psi and 1050-1000F. Main steam header was fabricated from 2¼ chrome, 1 moly pipe, 19" O.D. x 3½" wall.

Careful engineering, pre-planning and fabrication to high standards are the basic reasons why this job was erected with field welding and on-the-spot fitting held to a time-saving minimum. Contractor and owner both benefited from the ease with which the piping went into place—both saved money on the overall cost.

Complete facilities, engineering service, accurate fabrication that is quality control checked at every stage, plus erection service if desired . . . these are available to you on your next job. Take advantage of the *complete* piping services offered by Dravo. For full information, write DRAVO CORPORATION, PITTSBURGH 22, PENNSYLVANIA.

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Blast furnace blowers • boiler and power plants • bridge sub-structures • cab conditioners • docks and unloaders • dredging • fabricated piping foundations • gantry and floating cranes • gas and oil pumping stations • locks and dams • ore and coal bridges • process equipment • pumphouses and intakes • river sand and gravel • sintering plants • slopes, shafts, tunnels • space heaters • steel grating • towboats, barges, river transportation

1200 Temperatures entrusted to two L&N data systems!

At the new Bergen Generating Station of Public Service Electric and Gas Company, two 600 point L&N Data Systems will monitor bearing, boiler tube, and condensate temperatures for No. 1 and 2 Units.

Electric typewriters will log data for each unit on continuous 8½" wide log sheets, perforated every 11" . . . one typewriter logging all 600 temperatures while the other is recording off-normals (in red) and up to 10 trends. All inputs are scanned every two minutes for off-normals, with scanning proceeding during logging and trending. As an example of the system's safety measures, all data can go through either typewriter so the operator is never left without vital information.

In designing this system, Public Service and L&N engineers made a thorough study of Bergen's requirements. L&N's contribution was based on 30 years' experience in power plant measurements and an expert knowledge of data processing. For data systems and other power plant controls, call your nearby Field Office or Leeds & Northrup Co., 4972 Stenton Ave., Philadelphia 44, Pa.

Data Systems engineered to power-plant standards by **LEEDS** Instruments **NORTHRUP** Automatic Controls • Furnaces

New
CYCLO-TRELL
MECHANICAL
DUST COLLECTORS

These new Cyclo-trells can be built to fit any specific job. Available in Types C-10 (10″ diameter), C-24 (24″ diameter), IC (involute Cyclo-trell), ICL (involute Cyclo-trell, lined) and C-24-L (24″ lined). Also available: a new hopper discharge valve.

Write now for your copy of new Bulletin 300 which gives details and illustrations of the new Cyclo-trells and hopper discharge valve.

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3 PRESSURE CLASSES

1500-Pound ASA—in carbon steel (WCB)

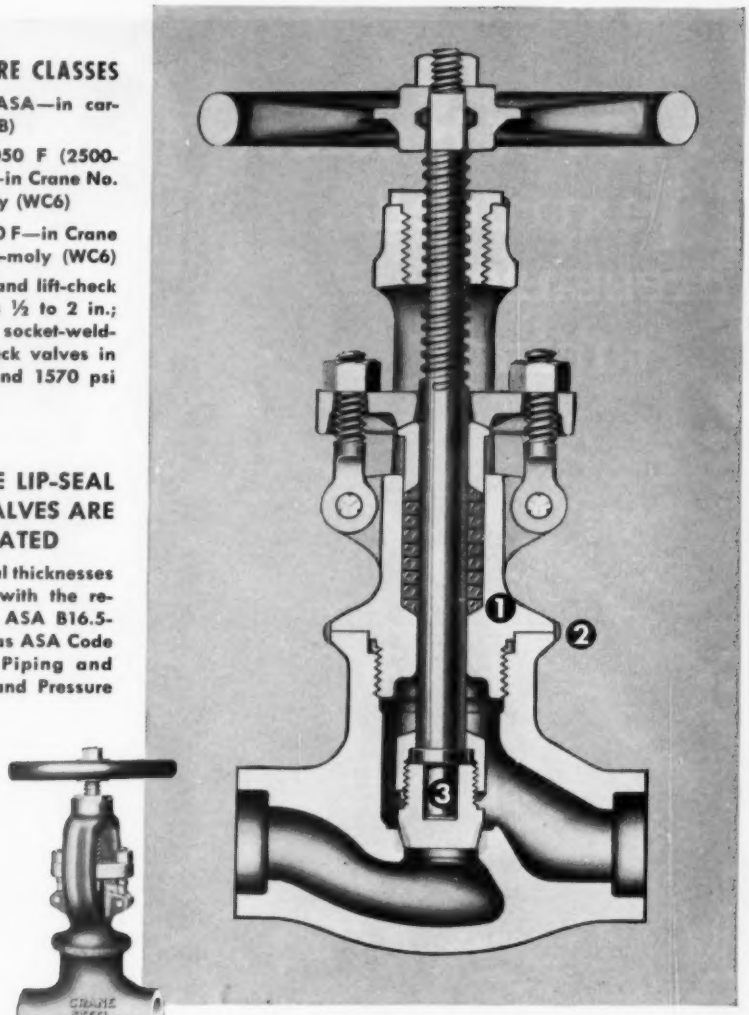
1570 psi, 1050 F (2500-Pound ASA)—in Crane No. 7 chrome-moly (WC6)

2520 psi, 1050 F—in Crane No. 7 chrome-moly (WC6)

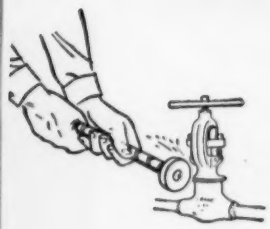
Globe, angle and lift-check patterns; sizes ½ to 2 in.; screwed and socket-welding ends. Check valves in 1500-Pound and 1570 psi ratings only.

ALL CRANE LIP-SEAL BONNET VALVES ARE ASA-RATED

Minimum metal thicknesses comply fully with the requirements of ASA B16.5-1957, as well as ASA Code for Pressure Piping and ASME Boiler and Pressure Vessel Code.



1 New centering shoulder assures perfect body-bonnet alignment. No chance of stem misalignment.



2 Welded body-bonnet Lip-Seal—eliminates bonnet joint maintenance. The seal-weld carries no mechanical load; it seals the bonnet joint only. Lip design permits convenient grind-off, easy rewelding.

3 Disc-stem connection. Improved design brings stem thrust closer to seating surface, minimizes vibration, does not interfere with swivel action of disc.

Today's ultimate in small high pressure valves —Crane Lip-Seal Bonnet Globes

These *accurately rated*, small high pressure valves—now in *three* pressure classes—meet all power plant service specifications for boiler feed, drips and drains, blowdowns, bypasses, and similar applications.

Here are compact yet rugged valves that provide precision throttling with minimum vibration of disc and reduced wear on seating faces—all with *low maintenance cost.*

The patented Lip-Seal bonnet alone gives these valves outstanding value. Strong, streamlined body . . . Stellite-faced, plug-type disc and seat . . . fully guided stem and disc . . . 2-piece, ball-type packing gland with stainless steel, swing-type eyebolts . . . these and more refinements all combine to make Crane Lip-Seal Bonnet Valves today's ultimate in their class.

For complete details, ask your Crane Representative for Bulletin AD-2373 or write to address below.

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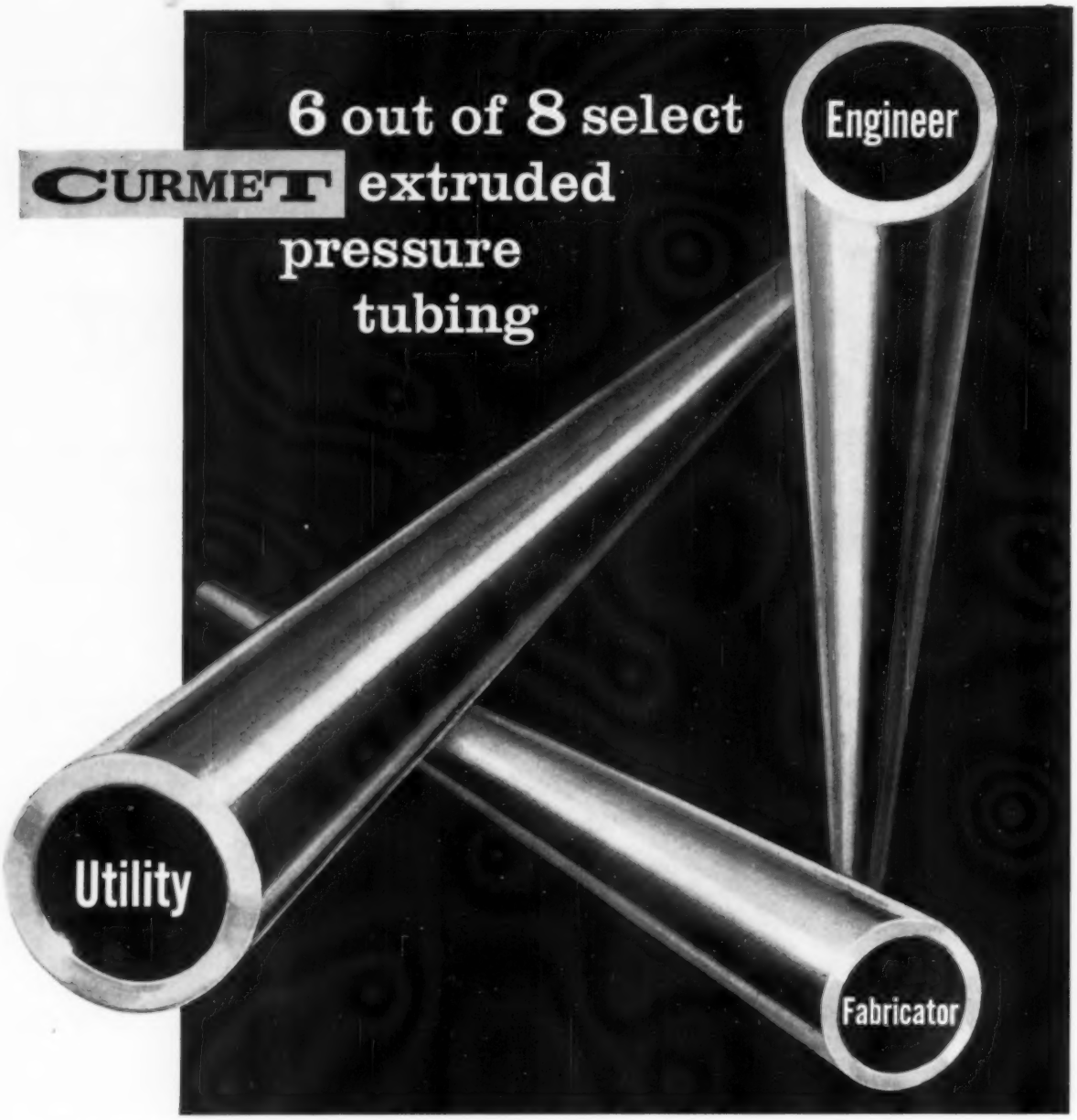
CRANE® VALVES & FITTINGS

PIPE • PLUMBING • HEATING • AIR CONDITIONING

Since 1855—Crane Co., General Offices: Chicago 5, Illinois—Branches and Wholesalers Serving All Areas



Six out of eight contracts recently awarded for new power plants specified Curtiss-Wright extruded pressure tubing for steam and reheat lines.

Utility, engineering firm and fabricator select CURMET tubing because its longer length reduces welds —because the metal itself is improved by the exclusive extrusion method. For example, keeping metal under 24,000,000 pounds compression forces flow in both axial and radial directions so that transverse and longitudinal strength are nearly the same.

The foresightedness of public utility management leads to the specification of materials that will stand up under ever-increasing operating temperatures and pressures. And equally as visionary are the engineering firms and fabricators who assist in the design and construction of these power plants for the decades to come.

CURMET tubing, from 8″ to 20″ OD, is available in premium grade carbon steels—chrome-moly, stainless and similar quality alloys.

Write for more complete information on this CURMET process—the superior properties—and the premium quality that it gives to metals.

CURTISS-WRIGHT CORPORATION 87 GRIDER STREET **METALS PROCESSING DIVISION** BUFFALO 15, NEW YORK

HAGAN NEWSLETTER
Behind the Panel

ONE-MAN WATER PLANT HAS HAGAN AUTOMATIC CONTROLS

With a half-year of full rated production behind it, this 12,000,000 gallon per day water purification plant has been on full automatic since the day it was put into operation. Flows, levels and pressures are registered on a unique U-shaped control panel, and one operator is in full control of the plant operation. Hagan PowrLog pressure transmitters, Ring Balance meters and Power Positioners provide the bulk of the control equipment. Flows are totalized, and the total raw water flow matches exactly the totals registered by the four filters, where flow into the clear well is measured. Planned for eventual expansion to a total of 72,000,000 gallons per day, everything about the plant was designed with this in mind. The Hagan control panel is equipped with space and piping leads to accommodate future instrumentation. Low maintenance costs and positive control, well protected by safety interlocks, are some of the reasons Hagan was chosen for this installation. (Item I-1)

KYBERNETES DATA LOGGERS MONITOR TWO PETROCHEMICAL PLANTS

Two Kybernetes systems are helping to keep a petrochemical complex "on stream" by continuous scanning of the reactor catalysts and reactor effluent temperatures. If preset temperature limits are exceeded, an alarm is sounded and the abnormal point is printed on a special log sheet. In addition, periodic printout is made of all temperatures being scanned. In one plant, 350 points are logged and monitored, and in the other 200 are monitored but only a select 180 are logged. This permits operators to compare input values against pre-set limits, and provides data for overall evaluation of the process. Analysis of long term trends may lead to adjustment of values to obtain higher production. (Item I-2)

HAGAN pH MEASUREMENT AND CONTROL FOR INDUSTRIAL APPLICATIONS

For such pH control applications as cooling towers, quenching tanks, water clarifier operations or other areas where the control of pH is essential to the process, the Hagan system provides a high degree of accuracy. The system consists of a standard glass electrode and preamplifier, plus a Hagan Model H-0 PowrLog receiver for recording and control.

Temperature changes in the measured solution are corrected for by a thermistor type temperature compensator. Two types of cells are available: one a Pyrex beaker for use where an immersion head is impractical, the other is a plastic head which may be used where water temperature does not exceed 194F. Providing measurement over a pH span of 2 to 12, the Hagan system is simple, easy to install and easy to maintain. (Item I-3)

COMBUSTION CONTROL SYSTEM--WITH A DIFFERENCE

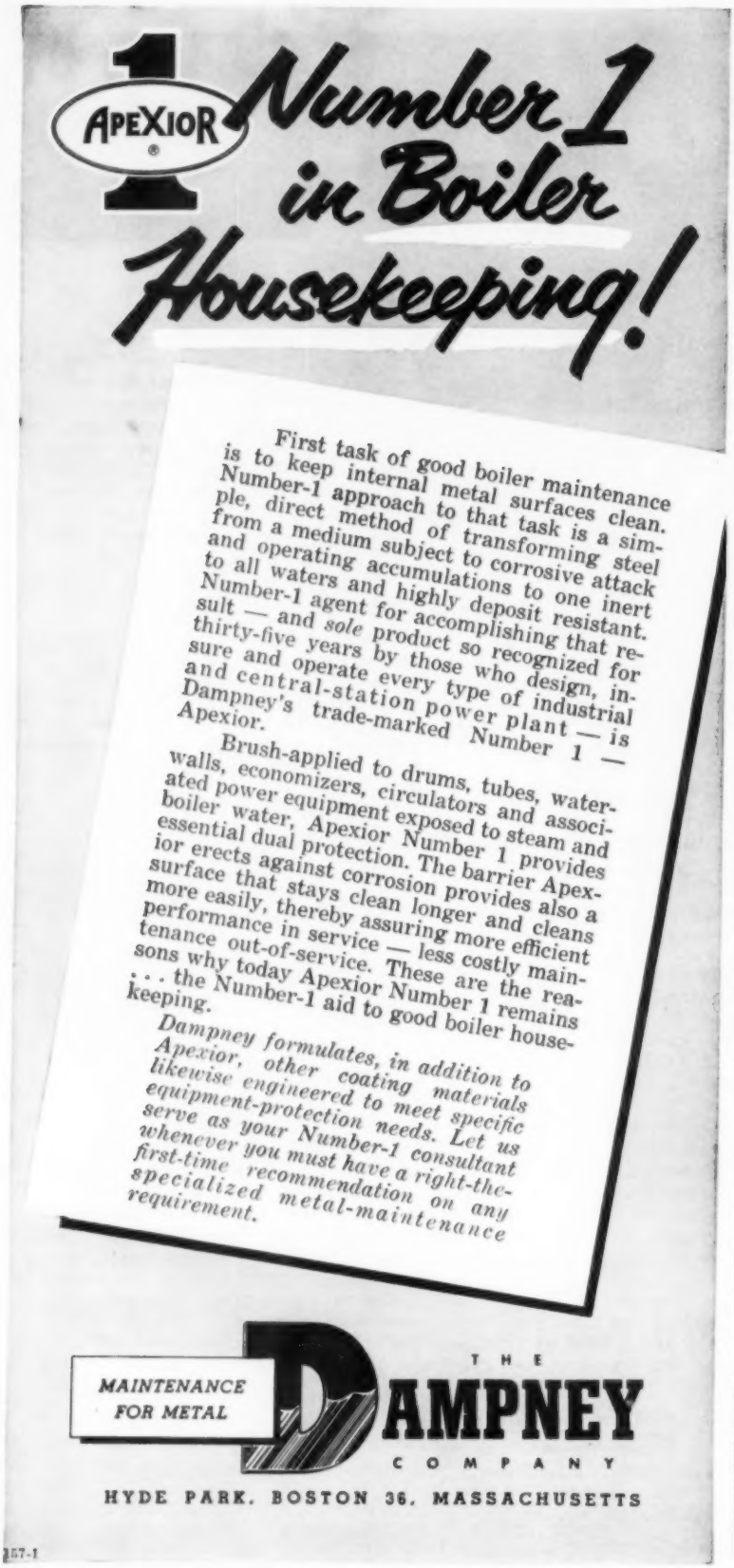
Normally, a combustion control system derives its primary control settings from the high pressure end of the system. However, at this major steel company, two boilers, each producing 250,000 pounds of steam per hour at 950 psig and 900F, are regulated from the low pressure side. This came about because pressure was dropped to 280 psig at the turbine, and this pressure was required for other steam uses throughout the plant. By exact control of the low pressure steam, turbine efficiency is also maintained. The system has been in operation for a little over six years, and personnel are enthusiastic over the accuracy with which the system operates. Pressures are maintained despite the fact that demand varies widely. Extremely low maintenance costs are another reason why the Hagan system has gained approval. To quote their instrument engineers, "You have only to look at Hagan equipment and you can tell the control philosophy on which it is based, and how it works. This makes routine maintenance a very easy task." (Item I-4)

HAGAN CHEMICALS & CONTROLS, INC.

Hagan Building, Room 708, Pittsburgh 30, Pennsylvania
In Canada: Hagan Corporation (Canada) Limited, Toronto
European Division: Via Flumendosa No. 13, Milano, Italy

If you would like more information on any of the above items, check the appropriate box below.

☐ Item I-1 ☐ Item I-2 ☐ Item I-3 ☐ Item I-4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First task of good boiler maintenance is to keep internal metal surfaces clean. Number-1 approach to that task is a simple, direct method of transforming steel from a medium subject to corrosive attack and operating accumulations to one inert to all waters and highly deposit resistant. Number-1 agent for accomplishing that result — and *sole* product so recognized for thirty-five years by those who design, insure and operate every type of industrial and central-station power plant — is Dampney's trade-marked Number 1 — Apexior.
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Dampney formulates, in addition to Apexior, other coating materials likewise engineered to meet specific equipment-protection needs. Let us serve as your Number-1 consultant whenever you must have a right-the-first-time recommendation on any specialized metal-maintenance requirement.
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Richardson *Monorate Distributors* for stokers prevent segregation in straight line of flow, without inverted spouts and restricted openings.

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That's what you *get* (not just expect to get) with the Clarage Type AF Dynafoil Fan...perfected for mechanical draft and heavy-duty applications such as industrial processes, conduit type air conditioning, tunnel ventilation.

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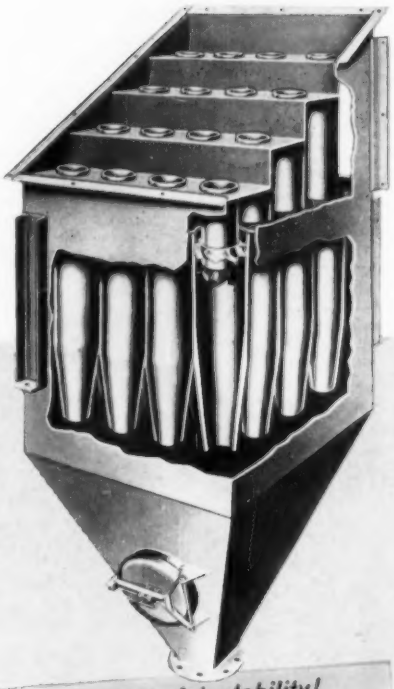

For cyclonic collection of dust or fly ash from all types of gases—hot or cold—no other equipment matches the *multiple* advantages you get in MULTICLONE Collectors. No wonder this small-tube equipment is so widely imitated—but only the genuine Multiclone combines so many important savings as these...

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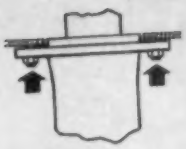
Multiclone Collectors pioneered the modern small-tube concept of cyclonic collection. The Multiclone small-diameter tubes combine highest collection efficiency with minimum risk of plugging—and separate not only large, medium and small particles, but also an unusually high percentage of the extremely small particles (10 microns and less)!



Compare Maintenance!

Multiclone cast iron tubes and vanes seldom require servicing or replacement. But when unusually abrasive service makes occasional servicing necessary, the tubes (one or more, as desired) can be quickly replaced by simply unbolting the old tube and installing a new one. The cast iron vanes are supported in a tapered seat—are equally easy to service!

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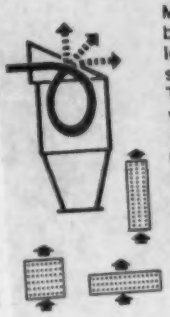
In addition to greater space adaptability, Multiclone Collectors also are unusually compact in themselves. For comparable capacity and performance, they require less floor space and less cubic space than do any other cyclonic units. Translate these space savings—plus Multiclone's adaptability to odd-shaped areas—into today's high costs for plant construction and you readily see how important Multiclone compactness really is!



Compare Adaptability!

Multiclone Collectors can frequently be placed in otherwise waste-space locations too small—or not properly shaped—for other types of collectors. The shape of the Multiclone can be varied—short and wide, long and narrow, or square—to fit varying space restrictions. Moreover, the unit can be installed with side-inlet, side-outlet—or side-inlet, top-outlet—to fit plant layouts...and only a single inlet and outlet duct is required to service an entire bank of tubes. These multiple advantages add up to important savings in installation, in insulating costs, in space conservation!

The Above Are Only A Few of the many important advantages you get when you install Multiclone Collectors. Still more are outlined in Multiclone literature that will gladly be sent on request. Write or phone our nearest office for this helpful information!

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